

THE HOTTEST PC GAMES OF 2022

apoc

SINCE 1980

**THE
CHAMPAGNE
YEAR AHEAD**

JANUARY 2022 #502

YOUR EXPERT GUIDE TO TODAY'S TECH

**ULTRA-
MOBILE PCs
THE HAND-
HELD MAKING
COMEBACK?**

**LAPTOP TESTS
SURFACE
PRO 8
PLUS NEW
MATEBOOKS &
ALIENWARE X17**

**2022
BUYER'S
GUIDE**

NEXT-GEN UPGRADE GUIDE

HOW TO MAKE YOUR 12TH-GEN PC PERFECT

- WHICH CPU IS RIGHT FOR YOU? • Z690 MOTHERBOARDS LABS TESTED
- DDR4 VS DDR5 RAM - DOES IT MATTER? • PCIe 5.0 - SSD SPEEDS YOU WON'T BELIEVE
- OVERCLOCKING AND TAMING THE TEMPS

FUTURE

0.95 INC GST NZ \$10.90 INC GST
POST APPROVED: 100000179
1725-4415



**HOW QUANTUM
COMPUTERS WORK
EXPLAINED IN A WAY
THAT WON'T MELT
YOUR BRAIN**

**IOT SECURITY:
PLUG THE HACKER GAPS
IN YOUR HOME DEVICES**



**OLD SCHOOL COOL
EMULATE
THE LEGENDS**

**ATARI 800, SINCLAIR
ZX80 & ZX81**

NBN SMB Solution for Ethernet WAN (FTTP, HFC, Fixed Wireless, Satellite)

DrayTek
Aust & NZ
www.draytek.com.au



Vigor2927 Series

Dual-WAN broadband routers with 1 x fixed GbE WAN port and 1 x configurable GbE WAN/LAN port, 5 x GbE LAN ports, SPI Firewall, 802.11ax/ac Wi-Fi, and 50 x VPN tunnels including 25 x SSL-VPN tunnels



50x

VPN

Vigor2927ax (AX3000)

- 1 x fixed GbE WAN port and 1 x configurable GbE WAN/LAN port for Failover, Load Balancing and High Availability mode
- Two USB 2.0 ports for connection to two 3G/4G LTE USB modems, FTP server, network printer and thermometer
- 5 x Gigabit LAN ports with multiple subnets and 60,000 NAT sessions
- 50 x VPN tunnels (including 25 x OpenVPN/ SSL-VPN tunnels) with comprehensive secure protocols
- Fast VPN throughput, VPN load-balancing and backup for site-to-site applications
- 16 x VLANs for secure and efficient workgroup management
- IPv6 & IPv4; Up to 1022 IP addresses and 8 IP subnets
- Integrated IEEE 802.11ax/ac wireless Access Point; dual band; up to 3000 (ax) or 867 (ac/Vac) Mbps throughput
- 2 x FXS VoIP ports (Vac model)
- High Availability mode
- Object-based SPI Firewall and CSM (Content Security Management) for network security
- Supports VigorACS 2 and VigorACS 3 Central Management Systems for remote management
- SD WAN capability when used with VigorACS 3
- Central VPN Management for 8 remote Vigor routers
- Central AP Management for deployment of 20 VigorAP's
- Central Switch Management for 10 VigorSwitches
- 2 years back to base warranty

Vigor2135 Series

Broadband routers with 4 x GbE LAN ports, SPI Firewall, 802.11ac Wi-Fi and 2 x VPN tunnels including SSL-VPN tunnels



2x

VPN

Vigor2135ac

- NBN (National Broadband Network - Australia) Ready to connect to NTD (Network Termination Device)
- 1 x Gigabit WAN port with 2 x USB ports for 3.5G / 4G Mobile Failover
- 4 x Gigabit LAN ports with 50,000 NAT sessions and IPv6
- NAT throughput over 600Mbps
- IPsec VPN throughput at 150 Mbps (AES 256 bits)
- Object-based SPI Firewall, Content Security Management (CSM) and QoS
- IPv6 & IPv4
- 802.11ac (AC1300) Wi-Fi up to 400 + 867Mbps speed (ac/Vac model)
- 2 x FXS VoIP (Vac model)
- 2 x VPN tunnels including OpenVPN/ SSL-VPN tunnels
- 2 x USB ports for 3G/4G Backup, FTP server, network printer or thermometer
- Supports Central AP Management for deployment of 2 Vigor Access Points
- Support VigorACS 2 and VigorACS 3 Central Management Systems for remote management
- 2 years back to base warranty



i-LAN Technology Pty Ltd trading as DrayTek Aust & NZ



www.i-lan.com.au



(02) 9838 8899



sales@i-lan.com.au

www.draytek.com.au

© Copyright 2021 i-LAN Technology Pty Ltd. All rights reserved.



SUBSCRIPTION ENQUIRIES

(02) 8227 6486
www.techmags.com.au
future@crmaus.com.au

Editorial

Editor: **Ben Mansill** ben.mansill@futurenet.com
 Senior Journalist: **Shaun Prescott**
 Journalist: **Joel Burgess**
 Creative Director: **Troy Coleman**

Contributors

Alex Blake, Jon Bolding, Niels Broekhuijsen, Rich Edmonds, Ian Evenden, Christian Guyton, Kenny Hemphill, Phil Iwaniuk, John Knight, Sam Lewis, Les Pounder, Phil Savage, Zak Storey, Chris Szweczyk, Tom Sykes, Ganesh T S, Jarred Walton, Mark Williams, Darren Yates, Robert Zak

Photography

All copyrights and trademarks are recognised and respected

Advertising

auadvertising@futurenet.com

Management

Managing Director: **Neville Daniels**
 Sales Director: **Paul Marttila** paul.marttila@futurenet.com

Printed in Australia by IVE

Distributed in Australia and NZ by Are Direct

ISSN 0725-4415

Future Publishing Australia

PO Box Q1179, Queen Victoria Building, NSW 1230

Corporate Web: www.futureplc.com

Email: apcmag@futurenet.com

Web: www.apcmag.com

We are committed to only using magazine paper which is derived from responsibly managed, certified forestry and chlorine-free manufacture. The paper in this magazine was sourced and produced from sustainable managed forests, conforming to strict environmental and socioeconomic standards. The manufacturing paper mill holds full FSC (Forest Stewardship Council) or PEFC certification and accreditation

All contents © 2018 Future Publishing Australia or published under licence. All rights reserved. No part of this magazine may be used, stored, transmitted or reproduced in any way without the prior written permission of the publisher. Future Publishing Limited (company number 2008885) is registered in England and Wales. Registered office: Quay House, The Ambury, Bath BA1 1UA. All information contained in this publication is for information only and is, as far as we are aware, correct at the time of going to press. Future cannot accept any responsibility for errors or inaccuracies in such information. You are advised to contact manufacturers and retailers directly with regard to the price of products/services referred to in this publication. Apps and websites mentioned in this publication are not under our control. We are not responsible for their contents or any other changes or updates to them. This magazine is fully independent and not affiliated in any way with the companies mentioned herein

If you submit material to us, you warrant that you own the material and/or have the necessary rights/permissions to supply the material and you automatically grant Future and its licensees a licence to publish your submission in whole or in part in any/all issues and/or editions of publications, in any format published worldwide and on associated websites, social media channels and associated products. Any material you submit is sent at your own risk and, although every care is taken, neither Future nor its employees, agents, subcontractors or licensees shall be liable for loss or damage. We assume all unsolicited material is for publication unless otherwise stated, and reserve the right to edit, amend, adapt all submissions.

Privacy statement

If you provide information about yourself this will be used to provide you with products or services you have requested. We may supply your information to contractors to enable us to do this. Future Publishing Australia will also use your information to inform you of other publications, products, services and events. Future Publishing Australia may also give your information to organisations that are providing special prizes or offers and are clearly associated with the Reader Offer. Unless you tell us not to, Future Publishing Australia may give your information to other organisations that may use it to inform you of other products, services or events. If you would like to gain access to the information Future Publishing Australia holds about you, please contact us.



Future plc is a public company quoted on the London Stock Exchange (symbol: FUTR)
www.futureplc.com

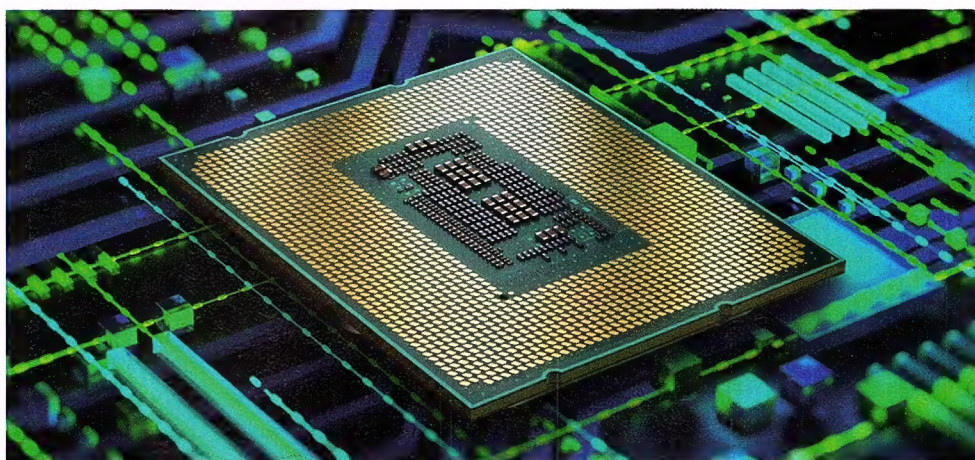
Chief executive **Zillah Byng-Thorne**
 Non-executive chairman **Richard Huntingford**
 Chief financial officer **Penny Ladkin-Brand**

Tel +44 (0)1225 442 244

INTRO

EDITORIAL

WHAT'S INSIDE APC



EDITORIAL

Choices, choices...

Next-gen conundrums



BEN MANSILL

Ben loves it when two industry giants face off in a battle to make the most incredible tech possible.

What an interesting proposition Intel's 12th Gen has turned out to be! On one hand, it's fantastic to have these tempting new CPUs to get excited about and weigh up compared to the alternatives – which not only include Ryzen choices – but also 10th and 11th Gen Intel chips, now that their pricing is so appealing.

But on the flipside – gee Z690 motherboards are expensive... and if you want some DDR5 memory good luck finding any at interesting speeds, or at a price that's competitive with going the DDR4 route.

There's a lot to think about, and we're here to help. Following on from last month's reviews of the launch 12900K and 12600K chips, we've expanded this month with a wider look at the whys and why-nots for those ready to pull the 12th Gen trigger. As he always does, Chris has done a beautiful job of breaking it all down and weighing up the options.

There's not a huge amount of Z690 motherboard choice right now, but we've pulled together a sample from each of the Big Four manufacturers and each board has had time in the Labs contributing to the mighty spreadsheet that tells us which one is best. As usual though, motherboard testing numbers reveal very little, I don't mind admitting. A couple of percentage points here and there do not make for a useful buying guide. So, make sure you read Chris' reviews for the real perspective. There's a lot between the different boards to consider.

Right now he's at it in the Labs testing DDR5 memory; that's a treat for you for next issue, though, because our publishing schedule compresses unpleasantly in the Christmas period and we have much less time to get the job done for a couple of issues, so we needed to spread that task out a bit.

Elsewhere in this issue we have a couple of particularly interesting laptops in. Joel has high regard for most Surface machines from Microsoft (though his review last month of the disappointing Surface Go 3 definitely shows there's no bias!). As it turned out, the Surface Pro 8 is a device that's going to be perfect for many.

Joel also has at the new Alienware X17, which I was surprised to see is a bit of a disappointment. Then there's the new MateBooks from Huawei. Both are reasonably good machines, but there's very defiantly a bias against that company we see and hear from many Aussie tech consumers. Can these machines stand on their own and win new fans?

It's been a huge year in so many ways, and I and the team here at APC hope there was more good than bad in it for you. Merry Christmas everyone!

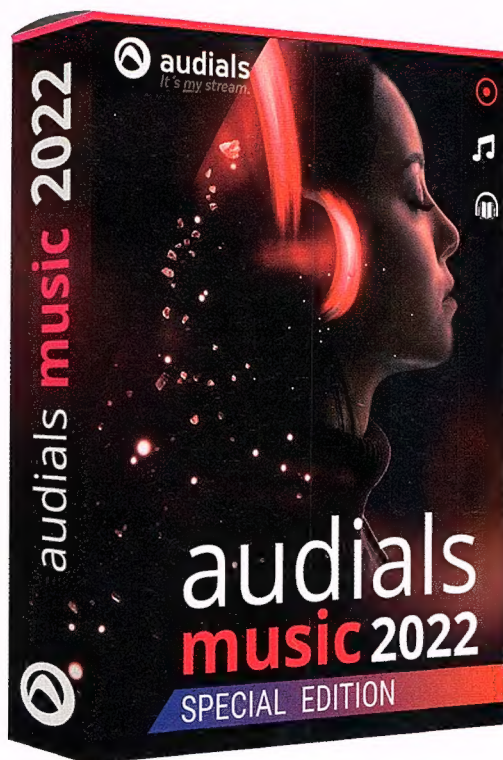
BEN MANSILL

DOWNLOADS

FREE FULL SOFTWARE FOR APC READERS

Exclusive downloads

Your free full-version apps as a thanks for reading APC. These exclusive downloads will only be available for a limited time, from 20/12/21 to 06/02/22.



AUDIALS MUSIC 2022 SPECIAL EDITION

Find and save songs from streaming services and video portals as private copies.

Millions of pieces of music cut exactly without loss of quality as in the original you can enjoy permanently in mp3. Got hundreds of songs or the complete discography of musicians? Audials saves everything in parallel and super fast and even invisible from Spotify and in real time.

Finding and recording pieces of music from every streaming service and in many versions becomes child's play, whether as a playlist, album or individual songs. From now on it is easier than ever to get playlists from video portals and Spotify displayed in Audials, download them and export any playlists if you wish. Limitless selection and always the right songs thanks to the latest artists and tracks. Immerse yourself in the infinite expanse of music! Get them from Audible, Spotify and Deezer and enjoy them on all devices.

Download link: www.apcmag.com/exclusives

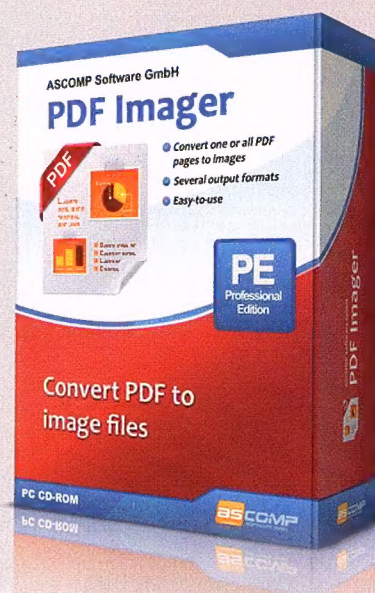
PDF IMAGER

Easily convert PDF pages into images and images to PDF files.

Anyone who should ever sign a PDF document knows the problem: How do I convert a PDF into an image file so that I can insert my signature graphic in Paint or Photoshop at the desired location? With PDF Imager, this is super easy! The software converts one or, if desired, all pages of the selected PDF document into an image file. The most common image formats are supported. In addition to BMP, JPEG and PNG, EPS, GIF and TIFF are available as target formats.

PDF Imager is also the ideal solution for conversions in the other direction! Create a PDF document from one or more images in no time – without the need for an expensive PDF editor! PDF Imager is characterised by its simple and intuitive interface – you save valuable time when converting your PDFs!

Download link: www.apcmag.com/exclusives



DISCLAIMER Future Publishing is not the licensor of the exclusive software or any documentation included with it. Rather, Future is merely a distributor of the software, and your use of the software is subject to any accompanying third-party licence terms. You must carefully read and comply with any such third-party licence terms, together with all instructions and README files that come with the software. Accordingly, to the maximum extent permitted by law, all software is provided by Future 'as is' and without warranty either express or implied, and Future will not be liable for any damage that you may incur as a result of using any software downloads. You should back up any important system and data files before using any downloaded software. We recommend that you do not use the exclusive software on a production machine. Nothing in this disclaimer excludes any warranty that may be implied by statute, which may include the Trade Practices Act. While we have taken all reasonable steps to check the software downloads for viruses, we cannot guarantee that it is free from viruses or other harmful code and you should check each download using a virus scanner complete with the latest antivirus updates before use.

More than just a charger

Fast charge + Auto backup



SanDisk® Ixpond® Wireless Charger Sync

More than just a charger, the 10W Ixpond® Wireless Charger Sync supports fast wireless charging for Qi™-compatible iPhone, Samsung and other smartphones while automatically backing up¹ your photos and videos in full resolution. Delivers up to 10W of power. Easily free up space on your phone, knowing your content is backed up right on the charger. It's that simple.

SanDisk®

Available from **Officeworks** 

1. Backup requires wireless connection, Ixpond® Wireless Charger app, and iOS 11 or above or Android™ 5.0 or above required. Ixpond Wireless Charger app available for download from the App Store or Google Play™. Registration required; terms and conditions apply. SanDisk, the SanDisk logo, Ixpond, and the Ixpond logo are registered trademarks or trademarks of Western Digital Corporation or its affiliates in the US and/or other countries. iPhone is a trademark of Apple Inc., registered in the U.S. and other countries. Samsung, Samsung Galaxy, Samsung Galaxy Note, and all Samsung Galaxy product series are trademarks of Samsung Electronics Co., Ltd. ©2021 Western Digital Corporation or its affiliates. All rights reserved.

PAGE 42



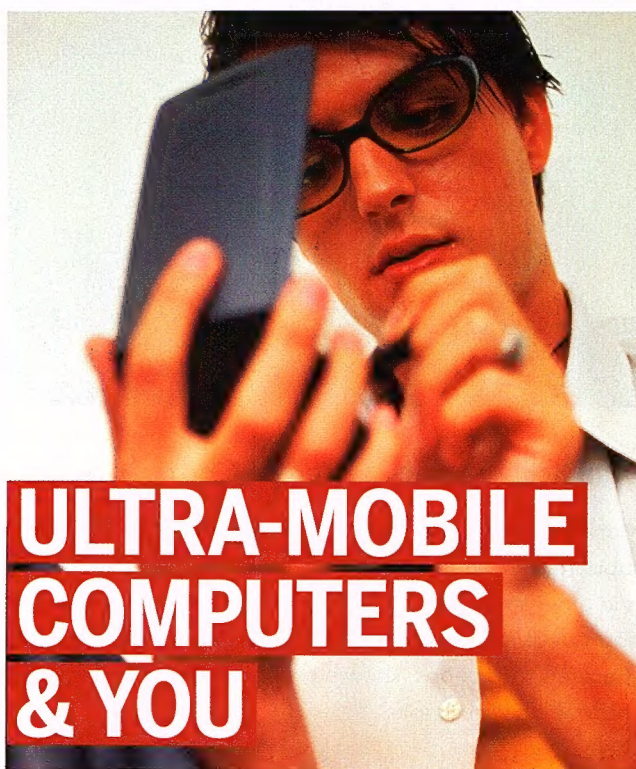
NEXT-GEN UPGRADE GUIDE

HOW TO MAKE YOUR 12TH-GEN PC PERFECT

FEATURE

THE GAMES OF 2022

What's coming to PC in 2022? Christian Guyton breaks down all the games we can expect to see next year **Page 68**



ULTRA-MOBILE COMPUTERS & YOU

From subnotebooks to Ultra Mobile PCs, these machines have come and gone over the years. John Knight asks if we are about to see their return **Page 60**



ALIENWARE X17

The X17 is hoping to offer big gaming performance in an extra thin package, but does this crash diet pay off in the long run? **028**



**ASUS ROG
RYUJIN II 360**
036



**D-LINK DIR-X3260
AX3200**
032



**HUAWEI MATEBOOK
X PRO**
027



**HYPERX CLOUD II
WIRELESS**
037



MICROSOFT SURFACE PRO 8

Is the Surface Pro 8 the only detachable anyone needs or is it just the last 2-in-1 tablet left on the market? **026**

TECHNOTES

- 10 News**
What's happening in tech
- 14 Tech brief**
8K screens and the future of high-DPI computing
- 16 End user**
Game remakes are great, but keep the originals, please
- 17 Random access**
Pirate bay for NFTs and the war between metaverse futurists and the right clicker counter culture
- 18 Two bits**
The global semiconductor shortage is still biting hard
- 19 Tech talk**
Win 11 HVC & VBS performance penalty
- 20 How it's done**
iPhone 13 Pro
- 24 Gadgets**
Techy toys and trinkets

THE LAB

- 26** Microsoft Surface Pro 8
- 27** Huawei Matebook X Pro
- 28** Alienware X17
- 29** Huawei Matebook D14
- 30** Nzxt H510 Flow
- 31** Corsair iCue 5000X RGB
- 32** D-Link DIR-X3260 AX3200
- 33** TP Link Deco Voice AX1800
- 34** Kingston KC3000 PCIe 4 SSD
- 35** D-Link DWA-X1850 AX1800
- 35** Sandisk G-DRIVE ArmorLock SSD
- 36** Asus ROG Ryujin II 360
- 37** HyperX Cloud II Wireless

FEATURES

- 42 Intel 12th Generation buying guide**
Tips, tricks and information to help you build the right Alder Lake system
- 68 The games of 2022**
What's coming to PC in 2022?
- 60 Ultra-mobile computers & You**
Could subnotebooks and Ultra Mobile PCs make a comeback?
- 52 Quantum computers are here**
The first quantum computers are being delivered. What will we do with them?

SOFTWARE

- 38** Windows
- 40** Apple Mac
- 41** Linux

PC BUILDER

- 74 System news**
Mark Williams sits down to watch the latest episode of the Core Wars: Intel Strikes Back
- 75 Market watch**
A sampling of PC systems available
- 76 Blueprints**
APC's best-value builds
- 79 PC builder masterclass**
Downsized 5950X

HOW TO

- 86 Quick tips**
Solving a variety of tech problems
- 88 Security**
Security and IoT
- 90 Macintosh**
Use Tab Groups in Safari
- 92 iOS**
Customise iPhone Backups
- 94 Linux**
8-Bit Atari 800 emulation

MASTERCLASSES

- 98 Pi**
Build a better file server with Pi – part 2
- 100 Coding**
MicroPython: coding your own hardware

DOWNTIME

- 102 Machine of the month**
Sinclair ZX 80 & ZX81
- 104 Gaming news**
What's happening, gamers
- 106 Gaming reviews**
High-performance playtime
- 110 Game changer**
Sin
- 114 Chip chat**
The less than serious news page



SUBSCRIBE NOW!

Turn to page 22 now to find out how



“Championing technology doesn’t mean we’re unrelenting yes-men and -women, however, and APC aims to be as objective as possible in all our coverage.”

HOW WE DO IT

Inside APC

Find out all about APC’s editorial policies, test practices, how to read the benchmark results, and more.

APC is Australia’s oldest consumer technology magazine – having been consistently in print for forty years, since our first issue way back in May 1980 – and we take that heritage and responsibility very seriously. While our focus is obviously on the personal computer the very definition of the PC has changed and shifted markedly since the early 1980s. As such, we touch on many other areas of tech, too, from smartphones and apps to peripherals, accessories, and beyond. We have two goals: to find the best modern tech and to help you make the most of it.

We’re also an open church in terms of platforms. We know most people aren’t wed to a single brand’s products and use a variety of devices. And, like you, APC’s journalists want to know what’s good in tech – no matter what platform it resides on.

Independent reviews

Championing technology doesn’t mean we’re unrelenting yes-men and -women, however, and APC aims to be as objective as possible in all our coverage. That means identifying the best products from multiple perspectives – the best performance, best value and best features and, ideally, the products that offer the best mix of these three attributes.

As a matter of policy, reviews published in APC are not shared with product-makers prior to print. We will contact vendors under certain conditions; for example, if we have a problem testing a product that seems to indicate it may be faulty, or to invite a vendor to clarify how a particular feature works. If an APC reviewer has any potential conflicts of interest involving a brand, the review will always be assigned to another writer.

Labs testing

APC strives to conduct the most rigorous, objective scientific tests and benchmarks we can so as to make our reviews as unbiased as possible. We use a variety of tools and programs for this, including many freely available benchmark suites for assessing media encoding, general system performance including storage read and write speeds, gaming and battery life.

In most cases, for the benchmark results published in APC, you can assume that higher is better. There are certain tests that deviate from this rule where the opposite is true; in those cases, we’ve flagged the results with a note explaining as such.

We use both tables and graphs for displaying results; the latter offers better ease-of-readability, but tables are more compact, so we use these in most cases where thoroughness is preferred. ■

APC TESTBED

The current APC testbed used in the Labs for benchmarking all components. This testbed is updated as new and relevant technology comes on stream.

CPU	AMD Ryzen 7 5800X
Motherboard	Asus ROG Crosshair VIII Dark Hero
GPU	Zotac RTX 3080 Ti AMP Extreme Holo
Memory	Crucial Ballistix Sport DDR4-3600 2x16GB
Primary SSD	Adata S70 2TB NVMe
Secondary SSD	Samsung 980 Pro 500GB NVMe
Cooling	Nzxt X73 360mm AIO
Case	Thermaltake Core P8
Power Supply	Corsair AX1000

APC AWARDS



APC EDITOR'S CHOICE

When a reviewed product scores 4.5 out of 5 or higher, it carries the Hot Award. These are products that exceed expectations and deliver a quality experience up there with the very best.



APC HIGHLY RECOMMENDED

You will see this award if a reviewed product has scored four out of five stars. It means most people can expect satisfying performance from the product, and that we would use it ourselves.

4G/LTE Dual-SIM Dual-Band Wireless VoIP VPN Router



CAT.6 

5GHz 1733Mbps
2.4GHz 600Mbps



BILLION

BiPAC 4520VAOZ R3



PERFECT CHOICE, GENUINE VALUE

Enables high-speed and secured Internet connectivity for home, SOHO, and enterprise users.

- ▶ 4G LTE Mobility
- ▶ Dual Radio/Dual SIMs
- ▶ 4X4(1733Mbps at 5GHz)/3x3(600Mbps at 2.4GHz)
- ▶ Automatic Failover/Failback between 4G/LTE and Gigabit EWAN



au.billion.com

☎ (02) 8318 3777

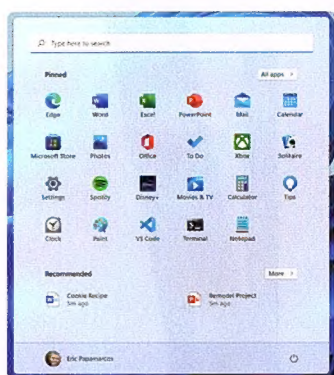
✉ sales@firstint.com.au

📍 Unit 35, 7-9 Percy Street Auburn NSW 2144

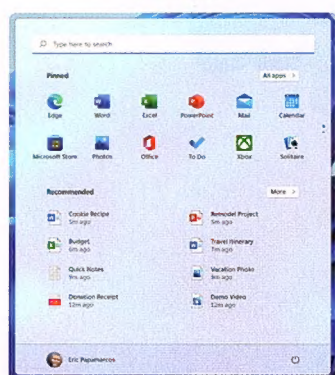
QUALCOMM BACKS ARM

How long can x86 continue?

Last year, Qualcomm bought Nuvia, a company founded by former Apple chip designers, for US\$1.4bn. With its own ARM-based Snapdragon chips making little headway outside smartphones, Qualcomm quickly got to work on new ARM designs. Apple has shown that a well-executed ARM design can work and Qualcomm has stated that a move to ARM-based chips is "inevitable". That may come as news to Intel and AMD, who are squeezing every drop out of x86 designs. The aim is to have samples of the next-gen Snapdragon chips ready by the summer, with commercial sales of notebooks following in 2023.



More Pins



More Recommendations

WINDOWS 11 DEV BUILD ADDRESSES START MENU COMPLAINTS

Irksome niggles get the flick.

Windows 11 Insider Preview Build 22509 just landed in the Insider program's Dev Channel, and it brings some meaningful changes to the UI along with a slew of bug fixes.

Perhaps the most noticeable change comes with the Start menu, which was criticised at launch for its lack of customisation options. Microsoft has addressed this complaint by giving customers three ways to configure the Start menu's appearance. You can keep the default layout that ships with Windows 11, but options are now available to select "More pins" or "More recommendations" in the Start menu. Each will show an extra row of either pins or recommendations, respectively. We don't know if this move will appease all Windows 11 Start menu haters, but it's a welcome step in the direction.



CHIP NEWS

The empire strikes back

But AMD's rebel alliance is ready for Intel's Alder Lake.

Intel has released the best of its new Alder Lake chips first, the headline-grabbing performance models. But what about the more affordable CPUs, the chips we stand a better chance of buying? Thanks to a slip up at Dell, among others, details of further Alder Lake SKUs went online well before the official launch. As expected, we have Core i7-12700, i5-12600, 12500, and 12400, and at the bottom the Core i3-12100. Curiously, the low-end chips don't appear to have any efficiency cores. An early benchmark of the i5-12400, with six performance cores using Adobe Premiere Pro, shows it stands toe-to-toe with a Ryzen 9 5600X. Alder Lake is proving to be a match for Zen 3 across the range.

What's next? Alder Lake mobile comes first, which has entered production, ready for launch around Q1. There are two versions; Alder Lake-P with a PBP of up to 45W and carries up to six performance cores, and eight efficient cores, along with DDR5, and PCIe 5.0 support. Alder Lake-M is the low-power version, which needs just 9W. Intel isn't resting there, with talk of the 13th-generation chips, code name

Raptor Lake, arriving next autumn. It will be socket-compatible with Alder Lake and features a 'new' hybrid design.

After this comes the main event, the 14th-generation Meteor Lake. Intel already has prototypes of this chiplet design running. This uses the Intel 4 process and is constructed using chiplets, or tiles as Intel calls them, with a processor tile (Ocean Cove), a GPU tile, and an I/O tile. The test chip also has a mysterious fourth tile (AI anyone?). The tiles use second-generation Foveros technology to stack other chips on top, making the complete package a 3D hybrid tile design. There are no solid numbers, this is still early days. It's expected to arrive in late 2022 at the earliest and will be a big step.

Meanwhile, over in the red corner, AMD's response is a new chip architecture, and Zen 4 will also be ready next year. Its CEO, Lisa Su, gave us a glimpse of the Zen 4 roadmap at its 'Accelerated Data Center' event, which was all about servers. Expect the desktop Zen 4 (Raphael) before the end of 2023, some leaked documents indicate it will have twice the L2 of Zen 3.



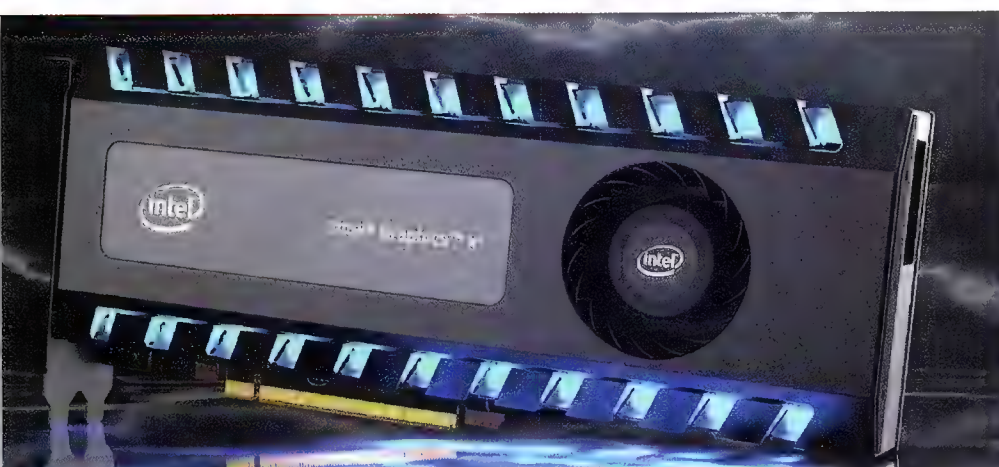


Compare over 1800
loans, savings &
insurance products

mozo.com.au



mozo
The money saving zone



Graphics duopoly all over

Rivals eye the lucrative GPU market.

For years, there has effectively been a GPU duopoly; Nvidia and AMD control roughly 80 and 20 percent of the market respectively. However, the growth of cloud services, AI, and other intensive HPC applications has fuelled a resurgence in GPU development. The most obvious new contender is Intel, which started developing its discrete graphics card business in 2017.

Early next year, we will see the first fruits: the Arc Alchemist (the DG2 as was). There will be four variants, the beefiest being the DG-512EU – sporting 512 EUs, this is aimed squarely at GeForce RTX and Radeon RX territory. Intel has hinted at a

price comparable with a GeForce RTX 3080.

Meanwhile in China, Xindong has previewed its Fenghua No.1 graphics card, and the spec sheet reads well: GDDR6X memory, support for the latest APIs, including Vulkan. The company is aiming the GPU at everything from data centers to desktops. Another Chinese company, Zhaoxin, has demonstrated a prototype discrete card.

Nvidia and AMD finally have competition and it can't come soon enough. We need more cards now and anything that might help push down prices is good news.

AI, and other intensive HPC applications has fuelled a resurgence in GPU development. The most obvious new contender is Intel, which started developing its discrete graphics card business in 2017.

HARD DISKS TO GO PCIe

Seagate begins move to faster data transfer.

Seagate has taken the logical step and demonstrated the first commercial hard drive that can connect to PCIe using the NVMe protocol, which added HDD support this summer. The result is an experimental drive with SAS, SATA, and NVMe controllers that works 'seamlessly', according to Seagate. Much of the impetus for the move comes from data centres, where NVMe is increasingly king, and moving everything to a single interface would be simpler, and cheaper.

Do spinning discs need a new bus on a home rig? Not yet, even the fastest still can't saturate SATA III, but it is getting closer by the year. The multi-actuator drives we've been promised for a while, and other improvements will outgrow their current home. Switching to a ready-made interface with acres of headroom is an obvious step.



The NFT Bay

Search NFTs | Browse NFTs | Recent NFTs | Top 100

Pirate NFT Search

THE NFT BAY DEBUTS TO SAVE YOU A RIGHT-CLICK

Precious digital art socialised.

A site called *The NFT Bay* has debuted to make "all the NFT's on the Ethereum & Solana blockchains" available to download via the visitor's torrent client of choice. The artwork associated with an NFT is just a file. There's nothing stopping anyone with a web browser from right-clicking on the NFT and downloading a copy of that art to their system. Now people won't even have to do the right-clicking themselves; all they have to do is torrent a bunch of art from *The NFT Bay*.

As *The NFT Bay* creator Geoffrey Huntley explains: "As web2.0 webhosts are known to go offline this handy torrent contains all of the NFTs so that future generations can study this generation's tulip mania and collectively go... 'WTF? We destroyed our planet for THIS?!'"

HASWELL KILLS DX12 GAMES

Nine-year-old IGP fades away.

Still running one of Intel's Haswell chips and playing DX12 games using integrated graphics? Then it's game over – the latest driver has pulled DX12 support. For anyone still needing support, Intel suggests reverting to an older driver. Haswell was a 4th-gen chip introduced in 2013, the range included a couple of tasty eight-core 'enthusiast' chips and clock speeds of up to 4.4GHz. It lived on after Skylake, and you could still buy a Haswell-based Pentium Gold earlier this year. We have become used to the rapid pace of technology, but eight years from cutting-edge to obsolescence is still impressive.

PC GAMER

THE GLOBAL AUTHORITY ON PC GAMES

**Over 22 million gamers
visit us online every month.**

Join them.

www.pcgamer.com

8K screens and the future of high-DPI computing

Why are computers the last in the evolution chain, after TVs and smartphones?

Microsoft has been pushing the idea of high pixel density computing since the release of Windows 7 10 years ago. That it hasn't happened yet is odd, because consumers are used to high-DPI displays on their smartphones.

That smartphone experience generates a sense of cognitive dissonance. Any handset launching with less than 300dpi would get laughed off the internet these days. But most PC users are lucky if their monitor manages 120dpi. Of course, smartphone screens are normally held closer than the typical viewing distance for a PC monitor, but not so as to make up for the chasm between the pixel densities.

Many smartphones have pixel densities of 400dpi or more, with some high-end models reaching 500dpi. Meanwhile, a typical 1440p 27-inch PC monitor manages just 109dpi. Even a 27-inch 4K monitor is only 163dpi. So why does this matter? It's not about content, at least not in the sense of video or gaming. Virtually no content exists that fully leverages the capability of a high-DPI PC monitor. You'd need beyond-4K resolutions, which presents numerous problems. For starters, the 8K format remains nascent. Besides a few pioneering broadcasts, such as the recent Tokyo Olympic games, virtually no TV is made in 8K.

Admittedly, a few movies are now shot in 6K and above, but they are still typically mastered in 4K or below. Special effects are rarely rendered in 6K or 8K, even when that format is used for the primary digital video capture. As for gaming, 4K presents a big enough challenge for today's GPUs, let alone 8K, which contains four times as many pixels as 4K, no fewer than 33 million pixels in fact. Compared with 1080p, 8K has 16 times as many pixels. That's 16 times the rendering load for a graphics card. It's a nightmare for any GPU.

So, the benefit of a high-DPI display isn't anything to do with

movies or games, at least not anytime soon. Instead, it's mostly about fonts. Text is much crisper and clearer on a high-DPI display. You get more desktop real estate or at least the option to create more depending on your preferences.

Question is, what level of pixel density is required to deliver a true high-DPI experience? That's a subjective call, albeit one based on empirical fact. It all hinges on the pixel density required to prevent the human eye from resolving individual pixels. Beyond that point, adding further pixels makes no difference. That, in turn, hinges on both pixel density and viewing distances. I'd say 200dpi is a pretty good rule of thumb. So, a 4K 27-inch monitor isn't a

million miles away. But it isn't quite there.

As ever in the PC monitor market, trends in TVs will drive prices down. It took a million cheap TVs before 4K monitors went mainstream. The same applies to 8K and thus affordable high-DPI computing. The prospects look good. Right now, the smallest 8K TV is 55-inches, which somewhat undermines the high-DPI remit. But a 40-inch set would deliver 220dpi. These days, they're pretty much giving away 40-inch 4K TVs.

Here's hoping, a few years down the road, the same will be true of 40-inch 8K sets and I can finally have the fonts of my fantasies.

Jeremy Laird ■

Many smartphones have pixel densities of 400dpi or more, with some high-end models reaching 500dpi. Meanwhile, a typical 1440p 27-inch PC monitor manages just 109dpi. Even a 27-inch 4K monitor is only 163dpi. So why does this matter?



Previous-gen 8K TVs, such as the LG Nano 95, now sell for around \$3,600.



The source for tech buying advice

techradar.com

END USER

Remakes are great, but keep the originals, please

A spit and polish can make an old game sing for newer players, but they shouldn't replace history, writes Shaun Prescott.

The first three 3D instalments in the *Grand Theft Auto* series got shiny new re-releases in November, improving everything from resolution and texture detail, through to how the guns feel. Anticipation was high in the lead up to their release, because it's no secret that these PS2-era games are pretty hard for a modern player to get a handle on: the combat emphatically belongs in the early 2000s, as does the lack of mid-mission autosaves.

But rarely does a new game release in 2021 without some form of controversy, and why should *GTA* be an exception? It turned out that the ports were in pretty bad shape at launch. Aside from the usual moderate performance issues such as stuttering, it emerged that port studio Grove Street Games had apparently used some form of machine-learning tool to upgrade the game's textures, resulting in some pretty amusing shop sign snafus, and some completely undermined visual gags.

There's no doubt that Rockstar will have the performance issues fixed, but the poor state of the trilogy's launch did have one positive side effect. Upon announcing the trilogy in September, Rockstar advised that the original versions of these games – emulated versions available on Steam, as well as the Xbox, PlayStation and Nintendo digital stores – would be removed from sale permanently. After the outcry concerning the remakes' condition, Rockstar backflipped and the originals are now back on sale.

This is a win for all who care about video games as a medium. These games were hugely formative and are about as museum-worthy as they come: they basically set the blueprint for a genre – the open world



On the left is the 'definitive' version. We prefer the original. It's less disturbing.

Rarely does a new game release in 2021 without some form of controversy, and why should GTA be an exception?

action game – that still dominates 20 years later. For enthusiasts to only have access to a version which, while ostensibly better, lacks the whole picture of what these games offered (and lacked) in their contemporary setting, is a huge blind spot.

Game preservation is important, and not just for historians or archivists: the average person who plays games for pleasure is just as likely to be curious about the history of an important series as, say, a film enthusiast might want to watch Hitchcock's *Psycho* over Van Sant's. Which is why it's important that the 1997 version of *Final Fantasy VII* remains available alongside the 2019 (partial) remake. It's why the old versions of the 8-bit *Dragon Quest* games need to exist in the emulation-sphere in concert with the (actually quite terrible) smartphone remakes. Those are just two examples.

Of course, Rockstar removing these older games from sale



SHAUN PRESCOTT
Author, *PC Gamer*
editor and passionate
technology observer.
Shaun covers trending
tech topics for APC.

doesn't erase them from the face of the Earth: physical editions exist, and those with a digital version can still access them. But their removal presupposes that games enthusiasts are mindless consumers who only care about the newest and shiniest thing. A lot of people are like that! But not all.

Possibly more alarming is the fate of multiplayer-only games. Respawn announced its 2014 shooter *Titanfall* – the game that indirectly spawned *Apex Legends* – will be removed from sale in November, and while servers will remain live for a while, they probably won't last. Meanwhile, what will happen to the swathes of online-only games like *The Crew* and *Hitman 3*? Grassroots online groups can revive discontinued online worlds like PlayStation Home, but what of the games that aren't as big, or important, or beloved? Enthusiasts have their work cut out for them, if preserving 21st century games is a job they undertake. ■

NFT culture clash: Who took the 'fun' out of fungibility?

Blockchain-based NFTs are proposed by some to be an important part of the future of the internet, but counter culture groups are trying to band against them.

If you hadn't already noticed, there's a war currently going on between futurists who wholeheartedly believe non fungible tokens (NFTs) are the key to the digital future, and those who are extremely offended by their very existence. The latest installment in this saga is the birthing of a new 'Pirate Bay' website for NFTs by Australian artist and programmer Geoffrey Huntley. The NFT Bay's manifesto states that it was created to store the files of all major NFTs "so that future generations can study this generation's tulip mania and collectively go WTF? We destroyed our planet for this?"

There's a bit to unpack here, but it really is a neat summary of the anti-NFT sentiment. Essentially there's a pretty solid groundswell of individuals who think that paying millions of dollars for a clip art image of a 8-bit colour rock is insane. Those people are objectively right. Only we're not sure anyone is actually arguing with them. Even the people that do own EtherRocks are often found describing them as nothing more than a 'flex' – a way to publicly burn money to show how much you're worth. Huntley's NFT Bay seems to think it's dunking on NFTs when it's perhaps proving the exact opposite without really realising. "Did you know that a NFT is just a Hyperlink to an image that is usually hosted on Google Drive or another web2.0 webhost?" the description section prompts "People are dropping millions on instructions on how to download images. That's why you can right click save-as because they are standard images. The image is not stored in the blockchain contract."

While there is a very real likelihood that NFTs and the cryptocurrencies they are built on are likely headed for another



JOEL BURGESS
When not reviewing PCs for *APC* and writing our funny pages, Joel likes to ponder tech and how it's used.

major correction, thinking that you somehow diminish an NFT's value by replicating it really just highlights a broad misunderstanding of the technology.

Basically any antique or collectible you can think of, doesn't generate its value by the material that shapes it or even the labor that went into it, but rather by its uniqueness and the value that people then ascribe to that. A signed football that was used in a grand final is going to have more value than another identical signed football that wasn't used. Thinking that by copying an NFT you'll somehow diminish its value is kind of like thinking that by taking a photo or even painting replicas of the Mona Lisa will affect the value of the one that hangs in the Louvre. As long as you can identify the original, it is going to maintain its value and that's all an NFT is, is a way to identify a specific

digital item.

Some heart on sleeve proponents of NFTs attempted to show this (in a particularly dickish way) by stealing 100 profile images of furry avatars from artists that were supposedly vocal proponents of right-clicking NFTs and collating them into an NFT that sold for 20 Ethereum (\$128,121). Naturally the furry community were upset with the copyright infringement and issued DMCA takedown requests to OpenSea, the marketplace that sold the NFT. The image is now only able to be viewed at lawsuitmaterial.eth.link, but the creator of the collage VincentVanDough did taunt the community with the Tweet: "NFTs are just a receipt they say, but that receipt lets us verify the creator and come to consensus on the original version no matter how many times it's reproduced or remixed. This ability would be useful to them now." ■

Basically any antique or collectible you can think of, doesn't generate its value by the material that shapes it or even the labor that went into it, but rather by its uniqueness and the value that people then ascribe to that.





TWO BITS

The global semiconductor shortage is still biting hard

And there's a China-sized elephant in the room.

We're all sick to death of the pandemic and its effects, and as I write this, news of the new Omicron variant is breaking, leading to head shakes and feelings that we're heading back to March 2020. Let's hope such thoughts are unfounded. As PC enthusiasts, we're all aware of the issues with chip supply, amply illustrated by the continuing insanity in the GPU market. Of course, it goes beyond that. All kinds of technology have been affected and it looks like it's not going to get better anytime soon if you listen to the likes of Intel and Nvidia CEOs Pat Gelsinger and Jensen Huang. It's bad enough now but there's something else that looms on the horizon.

Sooner or later the China and Taiwan issue is going to come to a head. And when that happens, other than the obvious catastrophic humanitarian and economic fallout, if Taiwanese – and to a lesser extent Chinese companies – go dark for any period of time, the current semiconductor supply issues will equate to KFC running out of sweet and sour dipping sauce. Large parts of the PC and smartphone markets will all but



CHRIS SZEWCZYK
A life-long PC tech enthusiast, Chris has worked across the industry in many areas as a product and technology expert.

shut down and the flow on and multiplier effects will add further devastation to a global economy that's barely afloat now, to say nothing of what will happen if there is all-out war.

Taiwan-based TSMC is the most advanced semiconductor manufacturer in the world. Its revenues neared US\$50 billion in 2020. Giants like Apple and Qualcomm spend huge amounts of money to ensure they get access to the best and most advanced nodes. It's a critical cog in the global electronics chain.

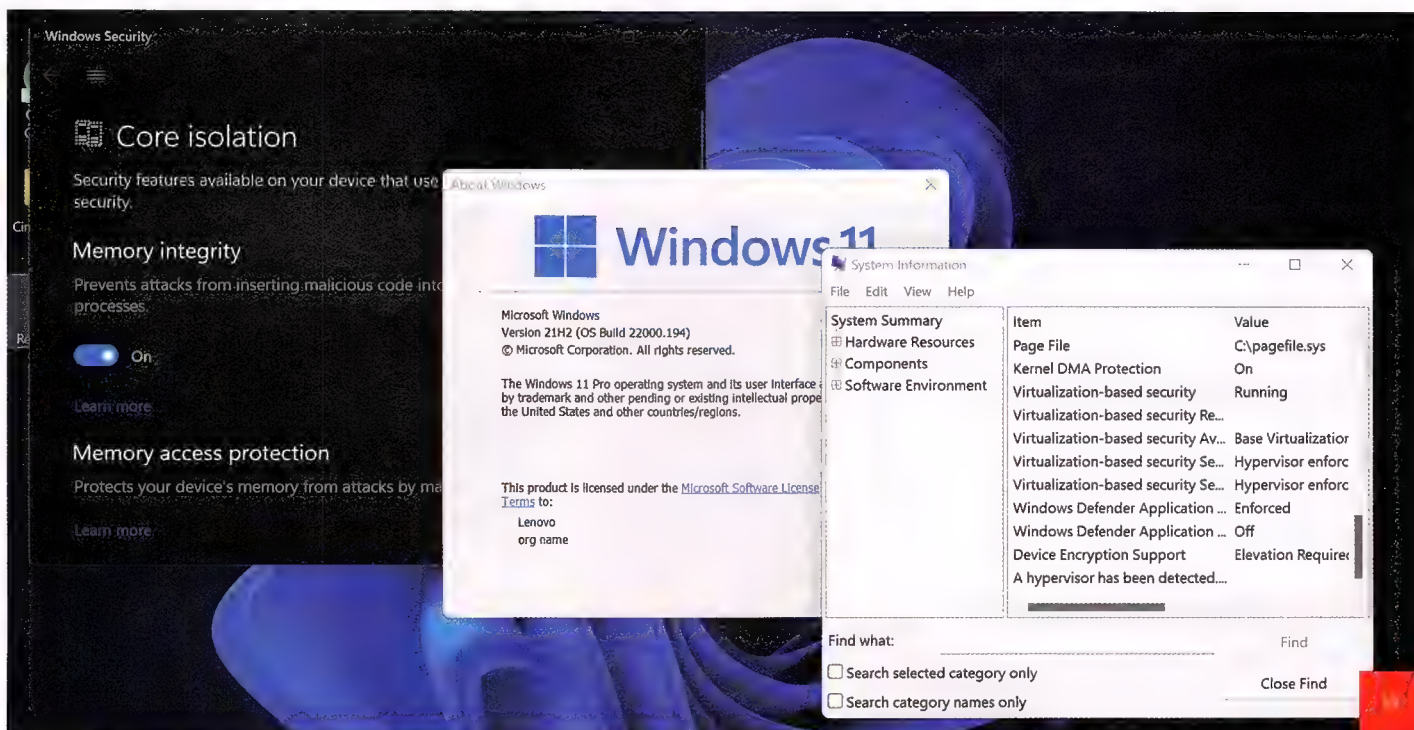
TSMC is just one company. There's Foxconn, the world's largest contract electronics manufacturer (and Apple supplier), ex-Asus company Pegatron, Asus itself, and many more. TSMC and the Taiwanese PC and electronics industries are just pawns in the game. China no doubt envies the technological prowess exhibited by Taiwan and it would love nothing more than to exert its influence even further over international companies that rely on Taiwan and China for their manufacturing. There are other macro issues at stake that are beyond the scope of

this article, but if there is war in Asia, things could get really ugly very quickly.

Some very large companies are taking steps to diversify their manufacturing. Samsung just announced that it's building a multibillion-dollar facility in Texas, just up the road from one of AMD's major offices in Austin. Coincidence? It may well be, but if Apple continues to throw its money at TSMC to secure 5nm and 3nm wafers, companies like AMD will have to look elsewhere. Samsung's 3nm might just do the trick, and at the same time, it would free itself from being caught in the China and Taiwan crossfire.

Should the Taiwan and China issue come to a head in the next few years, locking in some manufacturing outside of Asia seems like a prudent move, and given the way that semiconductor manufacturing and design are inextricably linked, if the likes of AMD and Qualcomm were to move to Samsung, it could already be a done deal. The next few years will involve critical decisions to protect global supply chains. Nothing to worry about or a catastrophe in the making? Let's hope not the latter. ■

But given the rather stringent hardware requirements for a proper Windows 11 installation – you need at least TPM 1.2 support, which rules out first-generation Ryzen CPUs and earlier AMD processors, and typically means you need at least a 6th Gen Intel CPU – there will undoubtedly be plenty of people sticking with Windows 10 for a while, including most businesses. In other words, it feels like the “skip every other generation of Windows” mantra remains. Windows 11 may join Windows 8 and Windows Vista in infamy. ■



HOW IT'S DONE

TAKING THINGS APART AND HAVING A POKE AROUND

iPhone 13 Pro

Battery swap success!

On the outside, this iPhone looks like an incremental update, but we have a feeling there's more lurking beneath the surface.

Major tech specs

- A15 Bionic SoC with a new 5-core GPU, 6-core CPU, and 16-core Neural Engine.
- 6.1-inch (2532 × 1170 pixels) Super Retina XDR OLED display with ProMotion.
- 12MP triple camera system with ultra-wide-angle (f/1.8), wide-angle (f/1.5), and 3x telephoto (f/2.8) cameras, LiDAR module.
- 6GB of RAM and 128GB of storage (configurable up to 1TB).
- Sub-6GHz 5G (and mmWave on US models), 4x4 MIMO LTE, 2x2 MIMO 802.11ax WiFi 6, Bluetooth 5.0, Ultra Wideband, and NFC.
- MagSafe 15W wireless charging.
- IP68 water-resistance rating.

Key findings

From the outside, the iPhone 13 Pro looks swollen compared with last year's model, but it's what's inside that counts. The camera bump means that the phone doesn't lay flush on a flat surface. Hopefully, the micrometers of extra focal length will help justify this Carolina Squat. We'll have to wait and see!

The 13 Pro inherits one of our favorite smartphone opening procedures. The display comes off first, like opening a slightly sticky book. Inside, we spot some labelling – it's almost as if they were expecting us! For starters, the digitiser and display cables seem to have joined forces. The upper sensor cable is off on its own near the top, and the Taptic Engine appears smaller than the 12 Pro's shaker, but it's bulked up, clocking in at 6.3 grams and 869.4 mm³, versus the 12 Pro's 4.8 grams and 764.27 mm³.

Unlike the vanilla iPhone, this year's Pro camera arrangement looks the same (and beefier than the 12 Pro's array). How will people know you've upgraded?! Maybe you should just... not?

This beefy L-shaped battery caps out at an expected 11.97Wh compared to the 10.78Wh obelisk in the iPhone 12 Pro (and non-Pro), but

loses out to the standard's 12.54Wh rectangular cell. The fancy Pro screens let them sip battery, leading to better battery life. After rumours that battery swaps wouldn't be possible, we're happy to report that our battery swap tests were successful. Apple hasn't given up its scare tactics, so you'll get a warning notification. Be brave and keep fixing!

Up top, we find the relocated earpiece speaker, complete with a snoot between the front-facing camera and Face ID hardware that connects to a channel that directs sound out the top of the display. With its cables running underneath the earpiece speaker (underneath the logic board) the front-facing camera hardware – the enabler of the new, shrunk Notch™ – isn't exactly a piece of cake to access. But, at last, we have arrived!

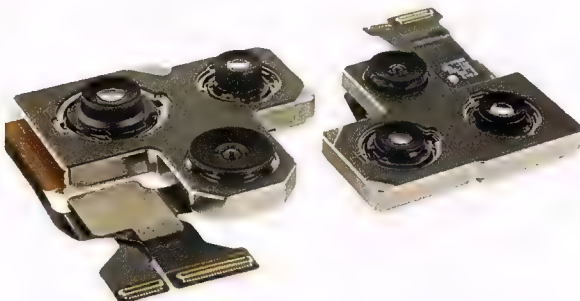
Repairability Score 5 out of 10 (10 is easiest to repair). Display and battery replacements remain a priority in the new iPhones' design. Most other components are modular and easy to access. The multitude of screw types makes repair more difficult than necessary, but at least they aren't glued. Waterproofing methods complicate some repairs but make water damage less likely. Double glass means double drop damage and, despite the improvements in durability, there's no easy way to replace the rear glass. Software component pairing complicates many repairs, undermines the credibility of third-party repair, and reduces critical functionality of the device when repaired without Apple's proprietary calibration tools. ■



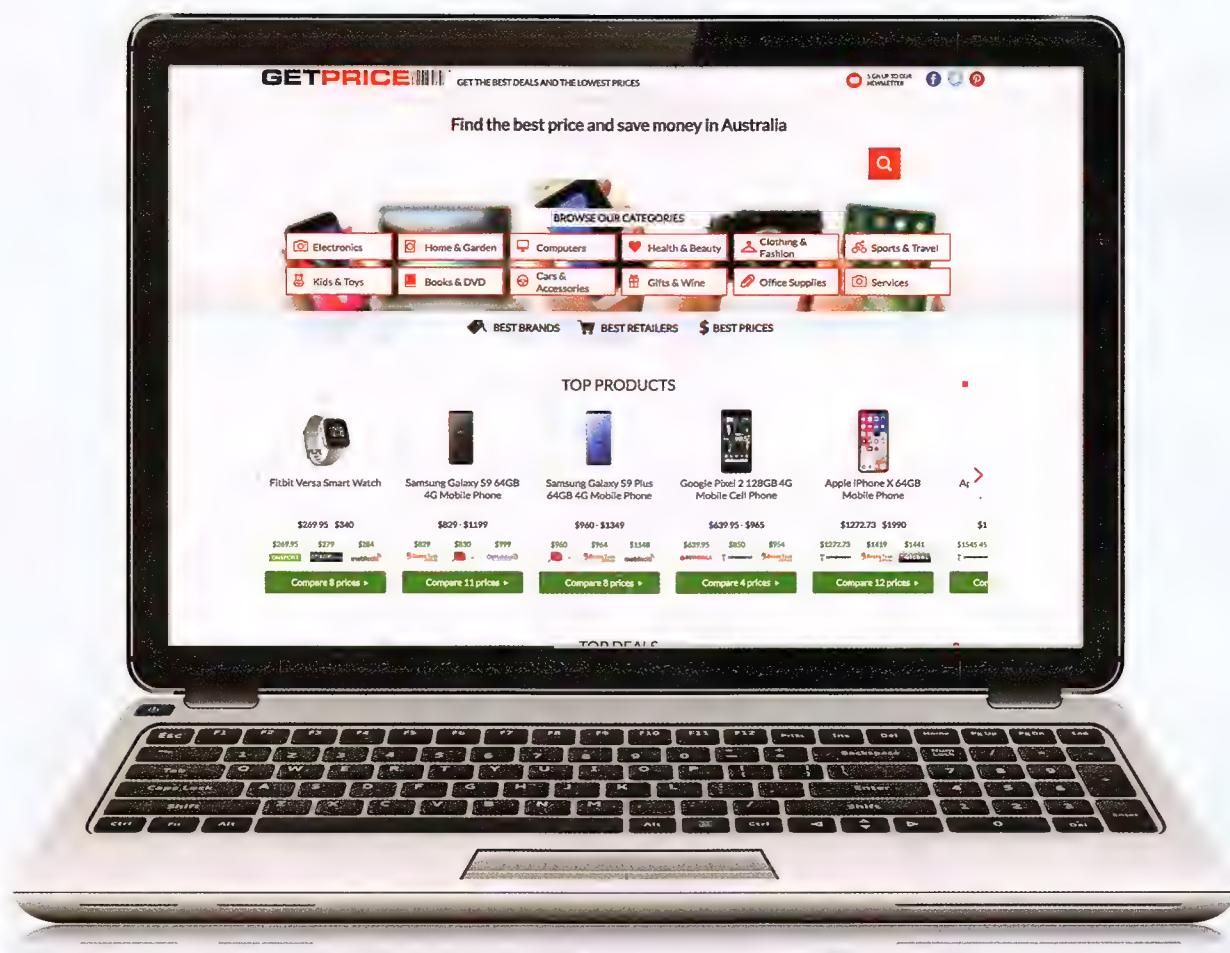
Removing the screen is, thankfully, an easy procedure with the right tools.



The layered logic board is even smaller this year, but unfortunately the SIM card reader is now baked onto the board.



Did someone say more cameras? However, there isn't much difference here compared with the iPhone 12.



Find the best prices
on the latest tech.
www.getprice.com.au

GETPRICE  TM

SPECIAL
OFFER

SPECIAL OFFER

Subscribe to *APC*

The go-to resource for PC enthusiasts



Simply scan the QR
code above with your
smartphone camera



All the convenience of *APC* delivered
direct to your door. Get the print edition
home delivered for a year for \$79

Save up to 47% off the newsstand price Get the print
edition home delivered 24 issues only \$139.00
– that's just \$5.79 per issue!

SPECIAL OFFER

APC digital edition also available

Subscriptions also available for Apple
and Android devices.

APPLE OFFER

Free 30 day APC
app subscription trial.
Read our latest issue
free today



The Apple edition for iPhone,
iPad and iPod touch
tinyurl.com/APCAPPLESTORE
From \$4.99 an issue

The Zinio edition for all
Android devices
apcmag.com
From \$4.99 an issue

Two easy ways to subscribe to APC magazine:

VISIT www.techmags.com.au or CALL (02) 8227 6486



SCAN ME

TERMS & CONDITIONS: This offer expires January 16th 2022, and is available to subscribers within Australia only. Please allow 6-8 weeks for delivery of your first issue. For full terms and conditions, see: <http://techmags.com.au/style/images/FutureTC.pdf> Please see our privacy policy on page 3. *Six issues for \$49, then \$49 charged to your credit or debit card every six issues thereafter on auto-renewal.playback); 32x22x1.7cm; 1.78kg.

GADGETS

NICE LITTLE THINGS



\$6,200 | vallkree.com

Vallkree Dual motor e-bike

An ebike with a Bond
boost switch.

Australian regulations mandate a maximum speed of 25km/h for assisted motorisation on e-bikes to be compliant on Australian roads, something that the Vallkree range of e-bikes are capable of adhering to using a single internal motor. But for those times when you happen to be off-road you can engage a second motor to deliver 1,000W of nearly motorbike level power. You can get up to 40km/h in off-road mode with a range of up to 50km on the 20AH battery. The bikes are a pretty cool cafe racer style and feature wide off-road tyres that are capable of tackling anything from dirt roads to soft sand.



US\$279 | petoi.com

PETOI NIBBLE

For anyone that wants to build
themselves a companion.

If you're keen on a Boston Dynamics Spot robot, but if you're more interested in teaching it to dance than you are to building a robot workforce, then you might be interested in a slightly smaller version that you can code yourself. Nybble, as this tiny cat bot is known, was built by a small companion robotics start-up called Peto alongside an 'open source robotic pet framework' called OpenCat. We're not convinced by the name, but the Raspberry Pi powered feline robot actually looks amazingly competent in videos, managing to navigate across terrain and remain balanced when pushed by humans or on an unstable floor.



US\$54,000 | vaonis.com

VAONIS HYPERIA

Your very own interstellar
telescope camera.

Vaonis, the makers of the highly regarded Stellina smart telescope are back with a new and improved stellar photography device called Hyperia. The Hyperia is a bit more pricey than Vaonis' two more approachably priced telescopes, landing at a pretty ludicrous US\$54,000, but considering its Sony IMX455 full-frame monochrome sensor offers around 10 times the megapixel resolution of its popular siblings we suspect it'll deliver some pretty amazing photos. The two meter telescope uses a smartphone app and onboard sensors to locate the popular galaxies, nebulae and clusters, so anyone from novices to experts can locate objects in the sky quickly and easily.

\$699 | sonos.com/en-au

Sonos Beam 2

The updated home theatre system will have you beaming, again.



A good soundbar is an awesome purchase for any home since it can double as a compact TV audio enhancer and your primary audio system, and the original Sonos Beam was one of the best you could get without getting into silly spending territory. The

Beam 2 builds on the successes of the original by adding Dolby Atmos compatibility and a new phased driver system that is able to position audio experiences around you in the room. The Beam 2

also gets Sonos' Trueplay technology that automatically adjusts output volumes to suit the room, and features an updated processor and eARC compatibility.

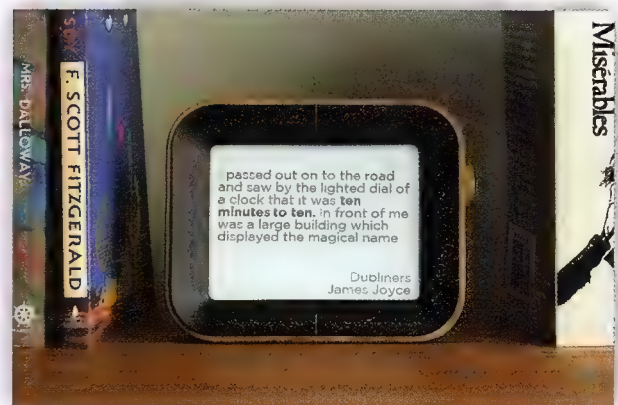


US\$349 | kck.st/3l2Migb

VAN DER WAALS FERROFLUID SPEAKER

A speaker that lets you see music.

If you haven't had the pleasure of watching ferrofluid (magnetic metallic liquids) react to music, we suggest you jump onto Youtube and explore that rabbit hole. The Van Der Waals Kickstarter isn't the only ferrofluid speaker we've seen but it is the first project that'll take your money in exchange for one of your own. The Van der Waals look like it's still early days since they don't show you the speaker actually responding to audio in the promo videos. But we've seen other prototypes online create a vibrant and responsive visualisation, so there's at least proof the concept could make a good Kickstarter project if they can make it work.



US\$149 | authorclock.com

AUTHOR CLOCK - A CLOCK THAT YOU HAVE TO READ INTO

Satisfaction is the death of desire.

Why just tell the time when you can set the scene for whatever it is you're doing using the words of the world's best writers. This clockwork orange will squeeze a juicy quote out every minute of the day, so you never have to feel like you're missing out on drama, even when on a deadline. If you're feeling a little more whimsical you can set it to 'vague mode' and let it hint at which part of the sun cycle you've found yourself in. The wireless e-ink display lasts three weeks on a single charge and the device will be constantly updated via Wi-Fi for new timely quotes.

\$2,399 | microsoft.com/en-au

Microsoft Surface Pro 8

Is the Surface Pro 8 the only detachable anyone needs or is it just the last 2-in-1 tablet left on the market?

Any computer that is updated every year is going to get a new set of processors, but it's generally what a company does outside of making the computer faster that determines whether you end up with a product that's ahead of its time or a bit of a flop.

The last few iterations of the Surface Pro have featured the same 12.3-inch PixelSense Display, so the Surface Pro 8 was well overdue for a refresh. Fortunately, the new 13-inch screen is bigger, faster and has a higher resolution than its predecessors, offering a 120Hz refresh rate and a 2,880 x 1,920 pixel resolution at 267ppi. All these extra pixels allow the screen to be 12.5 percent brighter, which is a welcome improvement that brings up the peak brightness to around 450 nits. The 120Hz refresh rate also makes a big improvement to the appearance of fast moving video and the overall responsiveness of the device.

The Surface Pro 8 is the first in the Surface range to get the Intel Iris Xe GPU, which means that slightly older or less demanding games are going to run really well using 1080p 'Low' settings. These novel gaming capabilities are complimented by the new 120Hz screen refresh rate, which will make less demanding titles run smoothly; this responsiveness benefits numerous other elements, like making drawing with a stylus feel more smooth and natural. You will have to enable the high refresh rate manually in Display Settings, since the additional frames will drain your battery faster than the standard 60Hz refresh rate.

While the Intel Core i7-1185G7



Specifications

Windows 11; 13-inch PixelSense 120Hz display at 2880 by 1920 pixel resolution; Intel Core i7-1185G7 CPU; Intel Iris Xe Graphics GPU; 16GB RAM; 256GB NVMe SSD; 50Wh battery (7h14min 1080p movie playback); 28.7x20.8x0.9cm; 891g (tablet only).

processor was launched more than a year before the arrival of the Surface Pro 8, it was still the current generation at the end of 2021 and it was an improvement over its predecessor. The quad-core CPU isn't quite as powerful as the top octa-core mobile processors, but it does have a high boost clock speed; it's more than powerful enough for photo editing and other demanding work applications.

It's hard to imagine the Surface Pro without the Type Cover keyboard, so it's nice to see that one of the most obvious improvements this year is a new pen with a housing built directly into the keyboard. The Surface Pro Signature Keyboard with Slim Pen 2 takes some of the best bits of earlier stylus design and improves on them with a slim ergonomic

design, haptic feedback, lower latency and improved software integration. The only downside is that the Slim Pen 2 costs \$189.95, on top of the \$259.95 Surface Pro 2 Signature Keyboard, so you'll need to factor in a hefty peripheral cost.

There's a larger 50Wh capacity battery on the Surface Pro 8 that did more than just balance out the additional screen energy draw, managing to last nine hours and 22 minutes in PC Mark 10 Battery Benchmark. This is a big jump from its predecessors and means you can expect a full work day's battery life from it. There's also updated Thunderbolt 4 ports and all the latest Wi-Fi 6 and Bluetooth 5.1 tech.

You do miss out on a Micro SD card slot and the device is 100g heavier and 7mm wider than its predecessors, but on the whole it's definitely a forward step, even if it does cost about \$100 more than the equivalent models from the previous year.

	Microsoft Surface Pro 8	Microsoft Surface Pro 7
PCMark 10 - Overall (score)	4,510	4,237
HWBot x265 - 1080p (fps)	23.363	23.979
3DMark Time Spy (score)	1,710	885
The Division 2 - Low 1080p (fps)	11	NA
Battery life - 1080p video playback (h:min)	07:14	05:56
Peak CPU temperature (°C)	82	96
CrystalDiskMark Read/Write (MB/s)	2,364	2,001
CrystalDiskMark Read/Write (MB/s)	1,085	831.8

A nice graphics, screen, battery and stylus upgrade to one of the only detachable 2-in-1s left in the market.

Joel Burgess

★★★★★



\$2,999 | consumer.huawei.com/au

Huawei MateBook X Pro

A few years ago Huawei was a dark horse that looked like it could take the local Ultrabook space by storm, but has it done enough to keep the MateBook X Pro ahead of the pack?

Dell's XPS 13 hasn't ever been pitched as a budget machine, but when you consider you could get a 13.4-inch 3.5K OLED display, 11th Gen i7, 16 GB of RAM and 512GB SSD for \$2,299 on sale at the end of 2021, the MateBook X Pro's \$2,999 price tag makes the XPS range seem positively affordable. Putting aside the fact that Google was banned from selling its Android operating system to Huawei, which meant many consumers suddenly had an ultra premium phone with a stop-gap OS, it's still not a particularly well-known brand in Australia, and Huawei would need a pretty astounding feature set to convince anyone to pay top dollar for one of its premium Ultrabooks.

The asking price of the MateBook X Pro lines up with the starting price of a MacBook Pro 14 (M1 Pro), which has a professional-level colour-accurate screen and uses a smartphone processor to outpace and outlast any laptop on the market. Since it launched the range locally at the end of 2018 the MateBook X Pro has

Specifications

W10 Pro 64-bit; 13.9-inch display at 3000 x 2000 pixel resolution; Intel Core i7-1165G7 CPU; Intel Iris Xe Graphics; 16GB RAM; 1TB NVMe SSD; 55Wh battery (7h50min 1080p movie playback); 30.4x21.7x1.5 cm; 1.33kg.

only really updated the processor, the trackpad and the speakers on the MateBook X Pro, so it's not looking like it's put all that much into R&D recently.

The 2021 Matebook X Pro has a 13.9-inch touchscreen display running at the same 3,000 x 2,000 pixel resolution as its predecessors. While the resolution is still more than adequate the 100 percent sRGB colour gamut is a little behind the vast majority of contemporary Ultrabooks, which offer DCI-P3 or Adobe RGB professional level HDR screens.

Powering the device is an Intel Core i7-1165G7 CPU, which is a perfectly adequate CPU, though most of the ultra premium devices offer a slightly higher clocked i7-1185G7 or above. This doesn't make a huge performance difference, but it does mean the MateBook X Pro is more

than 10 percent behind something like the Surface Pro 8 in raw media encoding or other CPU-heavy tasks.

While the earlier MateBook X Pros offered discrete sub-gaming graphics cards, they've been ditched on the latest model, since the integrated Iris Xe Graphics are capable of performance close enough to Nvidia's MX range of GPUs. It does make this MateBook X Pro cheaper than earlier models, but they lose their graphical advantage and still end up more expensive than current competition.

The 55Wh battery is pretty reasonable, with close to eight hours of movie playback and more than a full day's work lifespan. It's also got a nice keyboard and trackpad, the screen is brighter than most laptops, and the besels are particularly compact. It's wrapped in a nice metallic body and comes with a power button that doubles as a fingerprint reader. So there's still plenty to like, but we can't help but feel laptops have progressed a little more than the MateBook X Pro over the last few years, which means the top dollar price just doesn't seem reasonable any more.

	Huawei Matebook X Pro	Microsoft Surface Pro 8
PCMark 10 - Overall (score)	5,039	4,510
HWBotx265 - 1080p (fps)	19.439	23.363
3DMark Time Spy (score)	1,457	1,710
The Division 2 - Low 1080p (fps)	28	46
Battery life - 1080p video playback (h:min)	7h50min	7h14min
Peak CPU temperature (°C)	93	82
CrystalDiskMark Read/Write (MB/s)	3,649	5,246
CrystalDiskMark Read/Write (MB/s)	1,121	1,252

A premium laptop that hasn't delivered much innovation over the last few years.

Joel Burgess

★★★★☆



From \$3,899 | dell.com/en-au

Alienware X17

The X17 is hoping to offer big gaming performance in an extra thin package, but does this crash diet pay off in the long run?

There's a lot of finesse in an Alienware laptop, especially one of Dell's 2021 top-of-the-line 17-inch gaming rigs. The Alienware X17 is coated in a powdery metallic finish and offers a generously spaced 10-keyless X-series mechanical keyboard. It also offers components all the way up to an 11th generation Intel Core i9 and a Nvidia GeForce RTX 3080 GPU.

Dell is currently only offering the Core i7, 3060 and 3070 X17 models currently due to "higher than expected global GPU demand", but it will range the high-end devices again once the "backlog of orders" have been filled. Despite this, Dell did send us the highest spec 3080 model to review, which is listed as US\$4,779 in the U.S., or around AUD\$6,600 using current conversion rates. The entry-level i7 + 3060 on the other hand, starts at \$3,899 locally.

There's only a handful of laptops that really attempt to fight for the most powerful gaming rig crown, so it can get pretty competitive. Unfortunately, when you pit it up against something like MSI's

Specifications

W10 Home 64-bit (W11 ready); 17.3-inch 165Hz display at 1920x1080 pixel resolution, Intel Core i9-11980HK CPU; Nvidia GeForce RTX 3080 (165W); 64GB RAM; 1TB SSD; 87Wh battery (3h26min 1080p movie playback); 39.9x29.9x2.1cm; 3.2kg.

GE76 Raider, which was reviewed in APC 499, the Alienware X17 doesn't stack up all that well. While the X17 we reviewed had double the RAM allocation of the GE76 Raider at 64GB and a higher TDP of 165W on the 3080 GPU, it was more expensive, heavier, had a smaller battery, a smaller and slower SSD and a lower resolution 1080p 165Hz screen compared to the 1440p 165Hz monitor on the GE76 Raider.

When it came to performance on general work tasks the Alienware X17 was between eight and 16 percent better than the GE76 Raider usually, but at least some of that can be attributed to the larger RAM allocation, and in some CPU benchmarks the laptops were on par, with the GE76 Raider even ahead by up to 12 percent in one test. This means that all up there probably isn't a drastic difference in CPU performance

across these two Intel Core i9-11980HK units.

When it came to graphics capabilities we were a little surprised to find that the Alienware's higher powered GPU didn't improve gaming benchmarks or real world framerate performance. In fact, the Alienware X17 was outpaced by the GE76 Raider's 155W 3080 by between two and 10 percent in all the graphics tests we ran. The X17 GPU is likely to fare slightly better in more demanding 4K tests, but since the unit we were testing had a 1080p screen, comparing 4K performance seems a little redundant.

While the NVMe read/write speeds on the Alienware X17 were reasonable at 3,504/3,245MB/s they're about half the 6,698/5,302MB/s speeds you get from the GE76 Raider's NVMe 4 SSD. The smaller 87Wh battery also only offered three hours and 26 minutes of 1080p movie playback compared to over five hours on the GE76.

The Alienware is much thinner than the GE76, but it's still such a long way off being a true ultra portable that it doesn't really benefit the device that much – yet that slimness comes at the expense of just about every other parameter.

A gaming powerhouse that doesn't quite keep up with better specced competitors.

Joel Burgess

★★★★☆

	Alienware X17	MSI GE76 Raider
PCMark10 - Overall (score)	7,002	6,974
Cinebench R23 - CPU (multi-threaded)	13,920	11,922
3DMark Time Spy (score)	10,890	11,188
FT 2021 - Ultra 1080p (fps)	119	131
Battery life - 1080p video playback (h:min)	3h26min	5h21min
Peak CPU temperature (°C)	100	101
CrystalDiskMark Read/Write (MB/s)	3,504	6,698
CrystalDiskMark Read/Write (MB/s)	3,245	5,032



\$999 | consumer.huawei.com/au

Huawei MateBook D14

Is this sleek budget laptop a winning formula at mate's rates, or does that 'D' really stand for disappointing?

The Huawei MateBook D14 was released in 2020, but it is still the current budget MateBook model sold today. Unfortunately, while \$1,199 was probably a reasonable asking price when it launched, the 10th generation Intel Core i5-10210U CPU that powers it isn't far off being lapped twice by new processors. Walk into any major retailer and you'll be able to get a laptop with an equivalent 11th Gen processor for the same price and we've even seen comparable devices with i7-1165G7 CPUs go for hundreds of dollars less.

The MateBook D14 was on sale at the time of writing – knocking \$200 off the asking price – but even then, they're still not overly competitive. Two years of processor updates is a major sacrifice when you consider you'll probably only use this device for five or six years at most, so they really need to be on a \$400 discount to be even worth considering.

It's unusual for a budget device to feature an all metal chassis (generally

Specifications

W10 Home 64-bit; 14-inch IPS display at 1920 by 1080 pixel resolution; Intel Core i5-10210U CPU; Intel UHD Graphics; 8GB RAM; 512GB PCIe SSD; 55Wh battery (12h39min 1080p movie playback); 32.2 x 21.5 x 1.6cm; 1.28kg.

because it adds cost for non-essential elements), so if you could get it for cheap enough there might be an argument for it in the name of style. The FullHD IPS display is nothing to get excited about, but the bezels are reasonably compact for a budget device and the webcam relocation to the keyboard means that the 84 percent screen to body ratio looks relatively borderless.

The Intel Core i5-10210U scores up to 20 percent behind the i5-1135G7 processor on general home benchmarks, but in some cases the difference is negligible. Unfortunately the same can't be said for graphics capabilities, since the 11th generation processors get Intel Iris Xe Graphics which was around three times faster than the Intel UHD graphics on the D14.

While it doesn't have the latest spec PCIe SSD, the device still gets 2,377MB/s and 1,400MB/s read and write speeds, respectively, which is going to be more than enough for most people. And while there are more generous storage offerings out there, 512GB is still adequate for today's mostly cloud-based workflows.

The one major advantage of this device is that the processors are underpowered, and the 1080p screen isn't overly bright, allowing the 55Wh battery to get 13 hours and 16 minutes in PCMark 10 general work benchmarks and 12 hours 39 minutes for 1080p movie playback. This is one of the higher Windows-based lifespans we have on file and will be more than enough to keep you going all day.

The MateBook D14 has a nice enough keyboard and the trackpad is responsive and not overly sticky. There's also a fingerprint reader and the device is advertised as getting a free Windows 11 upgrade whenever that becomes available for 10th Gen chips, so it has some appeal.

	Huawei Mate Book D14	Surface Laptop 4 13"
PCMark 10 - Overall (score)	3,939	4,144
HWBot x265 - 1080p (fps)	22.678	25.848
3DMark Time Spy (score)	462	1,505
Geekbench 5 - OpenCL (score)	5,562	15,091
Battery life - PCMark 10 (h:min)	13:16	14:00
Peak CPU temperature (°C)	89	86
CrystalDiskMark Read/Write (MB/s)	2,377	2,230
CrystalDiskMark Read/Write (MB/s)	1,400	1,207

A dated budget laptop that looks good but isn't overly competitive.

Joel Burgess

★★★★☆



\$159 | nzxt.com

Nxzt H510 Flow

Compact brilliance.

We're big fans of small cases here at APC. There's just something about compact chassis that really hits home. For the vast majority who don't hoard TBs of data and process vast simulations or render video footage, a compact machine like this is all you really need.

Typically that means a small form factor, but ITX cases are difficult to work with, they require special considerations during the build process, and it does limit your ability to expand it later on. On top of that, micro-ATX rigs, although stellar back in the day, have also gone the way of the woolly mammoth, so for the vast majority a small ATX mid-tower makes a lot of sense. It's a perfect compromise.

Nxzt's H510 series of cases has been a popular pick for a long while now. The small compact design, with clean-cut lines, stylish colour picks, tempered glass, and a host of design features to enhance your building experience has cemented this case as a fantastic budget(ish) option for anyone looking to build a new system. The one weakness these cases have, however, is

Specifications

ATX, Micro-ATX, ITX; 2.5 / 3.5-inch Support 2+1; Max radiator 280mm front, 120mm rear; Fan Support 2x 140/120mm Front, 1x 120/140mm Top, 1x 120mm rear.

airflow. A solid front panel might look great for those social media snaps of your setup, but it's hardly conducive to good cooling. These case aren't without ventilation, the rear of the case has perforations along that edge, and there's a cutout underneath, but it's not quite what you'd call "airflow optimised". Enter the H510 Flow.

So what's new here? Technically, not much. The overall interior chassis is almost identical to the entire H510 line (technically the Elite's base chassis, as it has the solid metal plate running along the bottom of the front panel). You've still got a full-size PSU cover, still got the radiator bracket, the same cooling support, the cable tidy bar, and the smart cable routing in the back too. The material usage is pretty much the same as well, and there's the same support for storage also (a small 2 x 3.5-inch drive cage located in the bottom). Even the front I/O is the same, and there's still no

support for vertical GPUs either.

The big difference is that front panel. With its significantly larger perforations, the intention is clear and simple – allow better access to cool air. Does it work? Absolutely. You can check out how well it performed in our build this month (see page 79), but needless to say, it's a marked improvement over its predecessors. If you want the best performance out of it, we'd recommend removing that front dust filter, but then you will have to clean it more often.

So while not a lot has changed, it didn't really need to. This is already an exceptional case, that doesn't require any major update. It still doesn't support vertical GPUs, but realistically, that's not a huge deal-breaker. And besides, to have a case of this caliber for \$160, with an airflow option like this, that still looks as good as its solid panel siblings makes it super appealing.

The small compact design, with clean-cut lines, stylish colour picks, tempered glass, and a host of design features to enhance your building experience has cemented this case as a fantastic budget(ish) option for anyone looking to build a new system.

Good pricing, strong performance, intuitive design features with a clean look.

Zac Storey

★★★★★

\$279 | corsair.com

Corsair 5000X RGB

A majestic tower of glass opulence.

When Corsair announced its Obsidian 4000 Series cases, we particularly liked the glass 4000X for its superb RGB implementation and clean appearance, but it had one big drawback: thermals. With the Obsidian 5000X we have on the test bench today, Corsair addresses these concerns with an added intake on the right side of the case to aid the restricted front glass intake.

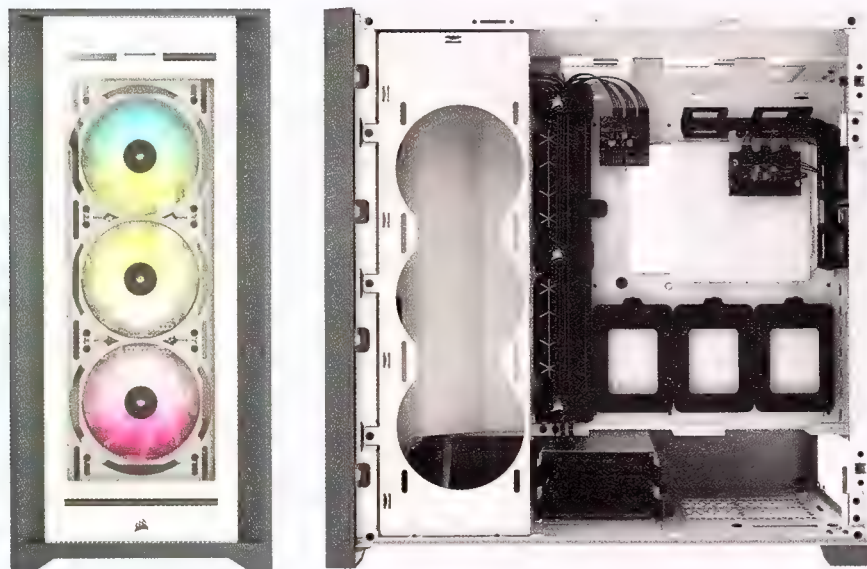
But priced at \$280, there's a steep premium you pay for this performance potential – and I say potential, because the chassis doesn't come with the added fans you need to get the increase in thermal performance.

Tempered glass is featured not only on the left side, but also the front, top, and right side of the chassis. The glass comes with quite a dark tint, which although it will hide much of your internal components, does have a few benefits: It hides ugly cables in plain sight. You won't need to get choosy with a pretty motherboard or GPU, and it masks unused space as well.

Inside the main compartment of the Corsair 5000X, there is room for up to

ATX-size motherboards, GPUs up to 420 mm long and CPU coolers up to 170mm tall. The space at the front of the case goes largely unused, though is of course necessary to create the clearance required to add the side intake. The rear of the system is covered up by a hinged metal door, which will work well to hide the cable clutter to keep things looking clean and tidy through the glass side panel.

If you want to populate all the fan slots, you'll be busy for a while as you can fit another three fans on the side, three 120mm spinners at the top (or 2x 140), and another 120mm or 140mm spinner at the rear exhaust.



If you want to populate all the fan slots, you'll be busy for a while as you can fit another three fans on the side, three 120mm spinners at the top (or 2x 140), and another 120mm or 140mm spinner at the rear exhaust. Of course, your AIO will probably take care of the top exhaust, but that still leaves another four fan slots open.

At the back of the motherboard tray there is a fan controller that splits a PWM signal into six headers, and an RGB header. The three included fans are connected to each of these controllers, leaving you room for three more. And that's where the problem comes in with this case. To use the added cooling potential it has over the 4000X, you need to purchase another three fans for the side intake, or else you might as well skip this case and go for the cheaper and smaller 4000X.

Corsair's 5000X RGB is, per usual Corsair fashion, well thought-out and a pleasure to use. It's a complete package, and although pricey, the build quality, ease of use, and looks are all there. Some might call it a bit boring, but to me Corsair is the Ikea of PC hardware – it's simple, easy to use, qualitatively good, and styled to match the majority of homes

A beast of an enclosure, offering a solid foundation for big, majestic RGB builds.

Niels Broekhuijsen

★★★★☆





\$300 | www.dlink.com.au

D-Link EXO AX3200

D-Link has delivered too many underwhelming routers in recent times. How will this affordable model fare?

D-Link's latest AX3200 Wi-Fi 6 router exists in the premium-budget end of the market, costing \$300. There are cheaper models and much more expensive models. So, should you consider buying it?

It looks like what it costs: not too plasticity but not overly premium either. It comes from the alien spaceship design school with many angular flourishes while four, long antennae offer the promise of half-decent performance. There aren't too many hardware features beyond four Gigabit LAN ports, a WAN port, WPS button and a power switch. There are no USB ports.

Setting up is simple via the 'D-Link Wi-Fi' app and a set-up card with a QR code. We were impressed that one of the first options available was to set it up as a standalone router or as a network extension node. Note, with the latter that buying two is unlikely to give you a cheap, two-node mega-mesh system, as there's no dedicated backhaul channel for stability. Still, we were keen to see how it performed and so ran our standard set of tests.

Stated, theoretical performance is 3,200Mbps spread over a 5GHz channel (2,400Mbps) and a 2.4GHz channel (800Mbps). Our tests involved setting up the router on the

Specifications

Speed: Dual-band AX 3,200Mbps | Connectivity: 4x Gigabit LAN, 1x WAN | Features: Alexa, Google Assistant, parental controls, QoS.

ground floor of our three-storey Sydney town house, next to our modem and Synology 1019+ NAS. We then downloaded large video files to our Dell XPS 15 OLED laptop up close, one floor up and then two floors up. Up close it managed an incredibly fast 813Mbps which is the second fastest score we've ever seen! One floor up, it tailed off somewhat, dropping to 142.5Mbps which is middling for a budget, dual-band router. Two floors up it fell to 83Mbps which is actually impressive for a budget model.

While we wouldn't advise buying it for large premises, the fact it's capable of blistering, close-range speeds while also offering Wi-Fi 6 capabilities like multiple connections to IoT, smart-home devices, means it will appeal to many people. But it's not alone in these areas, so what other features are there?

We were initially impressed with the offer to set-up both Alexa and Google Assistant. However, there's not much else. The app lets you see which devices are attached to your network, pause the internet, send you notifications and not much more. Fortunately, clicking on a device

offers impressive, profile-oriented parental controls that are based upon bedtimes or individual, 30-minute intervals. If you want standard features like QoS and Port Forwarding, you'll need to access the web browser-based options.

At \$300 it's a decent choice for people wanting to upgrade their home's Wi-Fi for speed, smart home and child-management features. There are other alternatives that have been on the market for longer, like the TP-Link Archer AX50 which costs \$50 less and has better performance at range (but not close up). But, we have to say, we're impressed with this D-Link. The company has produced several underwhelming, overpriced, budget devices in recent times but this hits a great sweet-spot for performance features and value.

Finally a winner from D-Link. The high performance married to a reasonable price and good features make this attractive to many domestic purchasers.

Nick Ross

★★★★★



deco



\$482 | www.tp-link.com/au

TP-Link Deco Voice AX1800 Mesh System

A Wi-Fi 6 mesh kit with Alexa speakers built-in? Sounds interesting.

There haven't been too many innovations in the Wi-Fi world lately, so we were happy when TP-Link's Deco Voice mesh kit turned up. It's a two-node, Wi-Fi 6 mesh system with a unique feature... built-in Alexa speakers.

We've seen Alexa compatibility before – D-Link especially likes to shout about it – but in those instances you'll need a separate, powered speaker to make everything work. In a world full of wires (even if they're mainly power cables) the more we can get rid of through integration, the better.

The Voice's nodes are similar to regular nodes but for a raised, blood-red plastic stand and an Alexa light ring at the top. To be frank, the stand will not be for everyone, but it's different, so we approve.

Specifications

Speed: AX1,800Mbps | Connectivity: 2x (2x Gigabit LAN) | Features: TP-Link HomeShield security, parental controls, Alexa speakers.

Set-up is simple via TP-Link's Deco app. You turn it on and allow Bluetooth to automatically connect. We tried to set up the second node upstairs but it wouldn't connect until we turned it on up close with the first node. After that, we moved it back upstairs and it was fine. The app is very simple and intuitive to use and gives a good overview of what's happening on your network. Adding Alexa functionality (which needs to be done for each node) simply involves signing into your Amazon account via the app and clicking a link. Once that's done, Alexa will listen to everything you say – very accurately and surprisingly well in a noisy room. Buttons on top turn off the speaker (it turns red), manually activate the speaker, and adjust the volume.

It all works very well and is very responsive. However, we can't help be a bit disappointed by the quality of the speakers themselves. Alexa's own voice sounds a bit muddy and indistinct unless you're in a very quiet environment. If you play music through them, you'll be very disappointed for similar reasons. There's also no bass to speak of.

All the usual, basic features are included in the app including decent parental controls that let you link people to devices. You can add HomeShield network protection which monitors private information, IoT devices,

malware and “teenage internet addiction.” Just note it's \$83 per year to subscribe.

We ran our usual performance tests in a three-storey, Sydney town house with the first node connected to our modem and a Synology NAS on the ground floor and the second node, one floor up. We downloaded large video files to our Wi-Fi 6-equipped Dell XPS 15 OLED laptop. Up close it managed a very impressive 575Mbps. One floor up it dropped to a below-average 136Mbps. On the top floor it struggled with a reliable signal and averaged just 79Mbps.

If you're regularly sending or streaming large files great distances, then you should probably look elsewhere. However, if you already use Alexa, or want to buy into it, these two speakers can be very useful in a modest-sized premises. At \$482, they're not cheap but considering the performance and features, the kit is still decent value.

Not the fastest performance, but the features, simplicity of use and Alexa functionality will tempt some.

Nick Ross

★★★★☆

Standard Alexa functionality is built-in, and that includes the light ring as well as a mic-mute button.



\$599 | www.kingston.com

Kingston KC3000 2TB M.2 NVMe SSD

As good an SSD as you can get right now.

It's been a while since we reviewed a high-end Kingston SSD. As one of the industry giants, Kingston drives are always worthy of consideration. A look at the specs indicates that this is a genuine high-end contender, and it should perform much like the Seagate FireCuda 530 we reviewed a few months back. Can the KC3000 challenge for the outright performance crown?

The Kingston KC3000 2TB is a 2280 (80mm length) PCIe 4.0 NVMe M.2 drive. Our sample came without much of a heatsink, apart from a thin metal strip. You'll need to install it under a motherboard heatsink to reduce the chance of throttling. It contains the latest high-performance Micron 176-Layer TLC NAND paired with a Phison PS5018-E18 controller, and includes 2GB of DDR4-2666 DRAM. The rated sequential read and write speeds for the 2TB KC3000 drive is 7,000/7,000 MB/s. 1 million read and write IOPS certainly look good on paper. All indications are that this is a top performing drive.

The 2TB KC3000 comes with a 1,600 TBW endurance rating. This is very good compared to both the 2TB 980 Pro and WD SN850 at 1,200 TBW but some way below the Seagate 530 at 2,550 TBW. The drive supports common features like trim and S.M.A.R.T. reporting, but not



Specifications

Kingston KC3000 2TB M.2 NVMe SSD; PCIe 4.0 x4; Phison PS5018-E18 controller; Micron 176L TLC NAND; 7000 MB/s sustained read, 7000 MB/s sustained write; 1M/1M read/write IOPS; 1600 TBW endurance; Five-year warranty.

AES256 encryption. Kingston includes a free copy of Acronis True Image home so you can clone your old drive over to the KC3000. You can also download the company's SSD manager, which allows you to perform common functions such as update the firmware or monitor the health of the drive. It's a perfectly functional piece of software, though perhaps the UI is a bit average compared to some other SSD software suites.

So, with a specification that matches our current favourite SSD, the Seagate FireCuda 530, how does the KC3000 stack up? Brilliantly. The KC3000 manages to beat out the Seagate in almost every test. It beats out the very highly rated WD and Samsung entries that feature very strong random read and IOPS performance. The Kingston easily takes its place as one of the fastest SSDs you can buy, if not the fastest of all.

The KC3000 does have an Achilles heel though. It runs very hot. We're a little surprised that Kingston isn't offering a version with a heatsink, though it may do in the future. It's imperative that you run the drive under a motherboard heatsink,

preferably one that has a bottom mounted thermal pad too. We saw a peak temperature of 78c, that hotter than the Seagate 530, and though within limits, it's a bit hot for our liking.

If you're looking for the fastest SSD you can get your hands on, look right here. The combination of 176L TLC NAND and the Phison E18 controller delivers stunning performance. Now we come to the price. On top of awesome performance, the KC3000 undercuts many of its competitors on price too. The Samsung 980 Pro can be found for cheaper, and that's no slouch, but the Seagate 530 is up to \$100 more, and that's tough to justify. If we were looking to buy a fast PCIe 4.0 SSD today, the Kingston KC3000 would be our choice. Just make sure you keep it cool.

Kingston delivers a stunning SSD that matches or beats its competitors in performance while also delivering great value.

Chris Szewczyk

★★★★★

			MSI Spatium M480 2TB	Western Digital Black SN850 1TB	Kingston KC3000 2TB	Seagate FireCuda 530 2TB
Crystal Disk Mark	Sequential Read MB/s		7,137	7,071	7,386	7,368
	Sequential Write MB/s		6,876	5,229	6,891	7,038
Anvil Storage Utilities	4K Random Read MB/s	Queue Depth 1	68.5	82.4	83.1	80.7
		Queue Depth 4	273.5	300.2	328.7	319.9
Anvil Storage Utilities	4K Random Write MB/s	Queue Depth 1	272.6	255.2	274.8	264.7
		Queue Depth 4	977.3	879.4	993.7	929.6
Anvil Storage Utilities	4K Random Read IOPS	Queue Depth 1	17,783	21,099	21,266	20,654
		Queue Depth 4	70,018	76,855	84,146	81,898
Anvil Storage Utilities	4K Random Write IOPS	Queue Depth 1	69,778	65,322	70,344	68,776
		Queue Depth 4	250,188	225,135	254,375	238,996
Internal File Copy	30GB of mixed file sizes	Time (seconds)	27	27	26	26
Final Fantasy XIV Stormbringers	Scene Loading Time	Seconds	8.109	7.680	7.561	7.674



\$150, www.dlink.com.au

D-Link AX1800 Wi-Fi 6 USB Adapter

It's been years since we've seen a USB Wi-Fi adapter. Is this Wi-Fi 6 model worth buying?

Specifications

Speed: Dual band AX 1,800Mbps | Connectivity: USB 3.1 Gen 1.

Back in the olden days when Wi-Fi was more often rubbish than it was stable, a next-gen, USB Wi-Fi adapter could represent a good upgrade. However, as laptops' antennae arrays got stronger and more complex, and as Wi-Fi technology has accelerated in terms of stability, performance and range, they've rather dropped by the wayside. But, there's certainly a market for them. Wi-Fi 6 can deliver fast peak transfer speeds and excels at communicating with numerous, low-powered, IoT, smart home-like devices without decimating the rest of your network's performance. We don't expect one to offer the range afforded by laptops' antennae but how does it perform in the real-world?

Firstly, it's really easy to set-up – the driver setup is accessed like a file on a flash drive. We plugged it into our Dell XPS 15 OLED's USB 3.1 Gen 1 port (which matches the USB drive's connection speed) and ran through our usual tests. These involved downloading files from our Synology 1019+ NAS drive, via D-Link's own AX3200 router (as seen on page 32): up close, one floor up and then two floors up. It managed an impressive 571.5Mbps, 68Mbps and then (just) 1.8Mbps respectively. To be frank, we were impressed it even connected at the top of our house. For such a small, convenient device these are decent results and could make a great difference if your computer's current connection struggles with raw performance or handling multiple devices. If that sounds like you, the \$150 price could be good value.

■
If you're struggling for Wi-Fi performance, this could be the simplest fix.

Nick Ross

★★★★☆



\$629 (2TB), \$TBA (1TB & 4TB)

Sandisk G-DRIVE ArmorLock SSD

Rugged build plus tight app-controlled data makes for good data security.

Specifications

1, 2 & 4TB; Interface: USB 3.2 Gen 2; Connector: USB-C; Compatibility: macOS 10.14+, iOS 13.2+, Android 9+.

The ArmorLock SSD is meant to be an always-encrypted SSD with seamless unlocking via Bluetooth (using either an iOS or Android app, or a Mac OS app). It is targeted towards use-cases where data protection and security are important enough without the need for a FIPS-certified drive.

It's designed to protect against dust and water ingress, and carries an IP67 rating. It's also rugged in nature, with a 3m drop resistance. Crush resistance ratings land at 450kg. The ArmorLock SSD needs to be associated with an app instance (on a mobile device or on a Mac), keys setup, and drive formatted before the volume is visible to the OS. The Android app is intuitive to use, and fulfils the one-touch unlock promise made by Western Digital for the product.

Performance starts off around 1,000MBps in this workload, but moves lower after running out of SLC cache after about 35 seconds. The direct-to-TLC write numbers are around 875 Mbps. The absence of S.M.A.R.T passthrough and TRIM support is a concern – hopefully, WD will be able to address that in a future firmware update.

The ArmorLock SSD is miles ahead of the competition in terms of performance and value – offering free features that are often subscription-only. The product is targeted towards content creators, studios, and business professionals, as well as IT managers in the finance, legal, healthcare, and government industries.

■
Strong data protection features along with reasonably good SSD performance make it a good security option.

Ganesh T S

★★★★☆



apc

EDITOR'S
CHOICE

\$399 | rog.asus.com

Asus ROG Ryujin II 360 AIO

This is one smart all-in-one CPU cooler.

The Ryujin II 360 AIO is an AIO with a 360mm radiator. It's designed with enthusiast use in mind, like overclocking an AMD Ryzen 9 or Intel Core i9 processor, but comes with some handy features everyone can appreciate.

Based on the usual Asetek design we've come to know and love from all PC brands, Asus went a little further by slapping a 3.5-inch display atop the water and pump combo block. This can show data like temperatures or system usage, as well as custom graphics and animations. It's quite the head-turner, especially when installed inside a case with a large glass side panel.

Asetek AIOs very rarely fail to impress, so we had high expectations of the Asus Ryujin II 360 AIO. Asus added a display and internal fan to the water block, and there's an included RGB controller hub.

If you're building a PC from scratch and want to connect numerous RGB components, this is a great foundation for not only overclocking your CPU but also creating an impressive-looking rig. Compared to the competition, you're

paying a small premium here for the newest Ryujin AIO.

The included three Noctua fans can be connected to the motherboard directly or via the controller hub. This can also be used for other RGB components you may have installed, keeping everything neat and tidy. Thankfully, Asus did ask for dark-coloured Noctua fans so we don't have to deal with the ugly brown standard design.

The AIO itself looks like your average liquid cooler until you reach the CPU water block and pump unit. It's massive. Not only did Asus include the 3.5-inch display but there's also an integrated fan inside the housing to help create some airflow around the CPU socket, which is an issue AIOs have compared to the traditional heatsink and fan solutions.

To test the AIO, we put together two separate systems, one with the Ryzen 9 5950X and another with a Core i9-12900K. Running both systems stock and overclocked led to impressive results. In-game we saw average temps of 43C for the 12900K and 49C for the

5950X. Stress testing all cores, the 12900K jumped to a very impressive 81C, while the Ryzen 58950X barely broke a sweat, at 65C. Overclocking added 10C to both systems – still well within tolerances.

Whether you want to simply do some work or play games, the 360mm radiator and pump combo will easily handle the most powerful consumer-grade CPUs from AMD and Intel.

The only complaint is the requirement to install the bloaty and difficult to uninstall Asus Armory Crate software in order to customise the huge display. Unless you happen to run a virtually all-Asus PC we'd have very much preferred a standalone app for a single Asus component's control.

If you have an Intel Core i9/AMD Ryzen 9 or better processor, spending money on coolers such as this is worth it, so you can extract as much performance out of these power-hungry CPUs without running into thermal trouble. The Noctua fans are brilliant and are able to achieve good airflow without emitting too much noise.

If you're building a PC from scratch and want to connect numerous RGB components, this is a great foundation for not only overclocking your CPU but also creating an impressive-looking rig.

There's plenty to like with the latest Asetek pump, a huge 360mm radiator, and three high-quality fans from Noctua.

Rich Edmonds & Ben Mansill

★★★★★



\$209 | hyperxgaming.com

HyperX Cloud II Wireless

Durable, comfortable and a reliable timeless design.

There is no denying that HyperX's Cloud headsets are super comfortable, although visually, this isn't the most advanced design. There's no faulting HyperX's formula here – take an already great gaming headset and add wireless functionality to the mix.

The mainly aluminium structure provides a durable build quality, while still having a flexible padded headband. As far as the cups go, if you have ever used HyperX headsets before, you'll already know, but these cans are soft and comfortable. Thick memory foam coats your ears and while back in 2015, the original Cloud IIs were one of the most comfortable gaming headsets on the market, we can still say the same today. They aren't the lightest headphones we've tested, but they are absolutely fine for a long session, with no noticeable pressure on your ears or head.

The majority of functions are on the left cup. There's a power button, mute button, USB-C charging port, and also the detachable microphone jack. To differentiate the two buttons, the power button is indented and the mute button is the opposite. This is great for mid-game changes when the last thing you want to do is turn your headset off when attempting to mute.

Specifications

53mm dynamic driver w/ neodymium magnets; Frequency Response 15Hz-20,000Hz; Impedance 60ohms; Connectivity 2.4GHz wireless USB.

The power button also acts as the virtual 7.1 surround button and you press it once to cycle on/off. On the right side is where the volume wheel is located, this has a nice texture to it for precise volume knob action. If we're being extremely picky, we'd prefer to see this on the left cup, so that you can make adjustments and keep your hand on the mouse when gaming (apologies to lefties).

The microphone is a detachable bendy mic that comes with an LED mute indicator on the end. The audio quality is nothing ground-breaking but will be more than decent for some party game chat. Like most detachable headset mics, it's adequate, though it can be a little tinny at times.

Let's talk sound because this is what matters. This headset seems to hit a balanced sweet spot. You get a nice warm bass that isn't too in-your-face with these cans. It's there when you need it and it can hide away in intricate moments of gaming. The highs are detailed and they help to create a great audio aid with pinpoint directional sound when gaming. No one element of the soundstage overshadows the others, giving these

headphones a well-balanced presence.

The virtual 7.1 surround also produces an immersive environment when gaming and watching films. This headset isn't the best for listening to music, and when the volume is cranked all the way up, the highs can get a little harsh, but they aren't necessarily made for music. Going wireless hasn't taken anything away from the originals, which is a positive.

The HyperX Cloud IIs aren't revolutionary, they aren't groundbreaking and they aren't anything brand spanking new. However, they are a slightly modern upgrade to an already great-sounding gaming headset. Sure, they only have one form of USB wireless connectivity that restricts compatibility, they aren't jam-packed with modern features and they may not be to everyone's visual taste.

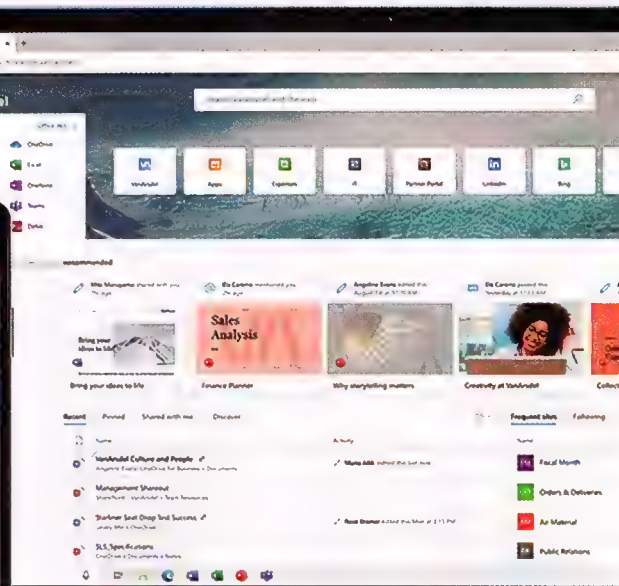
Nicely balanced sound and pillow-like comfort, though the mic is average at best.

Sam Lewis

★★★★★



Decades ago it was Internet Explorer. Now, it's Edge. Microsoft seems hell-bent on getting people to use its browsers, even by force.



WINDOWS/BROWSER

Microsoft forcing people to use Edge is familiar, frustrating, and foul play

Microsoft is using the dominance of Windows to force people to use a certain web browser ... again.

Microsoft recently explained why it prevents apps like EdgeDeflector from intercepting links that open Microsoft Edge. In addition to its statement not adequately justifying such a stance, it also fails to address a bigger issue – that people should be able to use their own default browser.

Windows 11 uses edge://protocol links in certain elements of the OS, such as the News widget. These links open in Microsoft Edge even if you have a different browser set as your default. Until recently, EdgeDeflector could intercept these types of links and redirect them to whichever browser

people would like. Microsoft was apparently unhappy with this, as well as the fact that Mozilla was working on a similar feature for Firefox. As a result, the tech giant “fixed” the “improper redirection.”

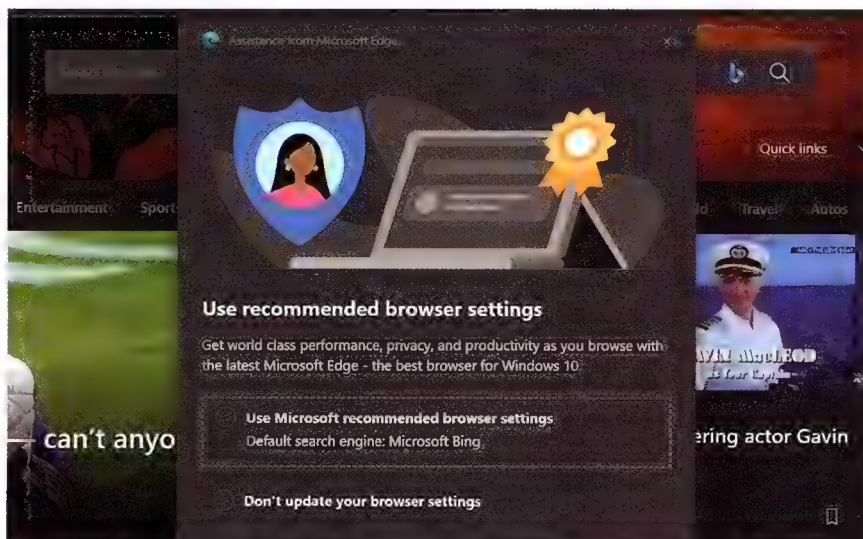
Before I dive into the situation, here's the statement a Microsoft spokesperson provided about the topic:

“Windows openly enables applications and services on its platform, including various web browsers. At the same time, Windows also offers certain end-to-end customer experiences in both Windows 10 and Windows 11, the search experience from the taskbar is one such example of an end-to-end experience that is not designed to be redirected. When we become aware of improper redirection, we issue a fix.”

To paraphrase, Windows lets people use non-Microsoft applications to perform tasks, except when Microsoft wants people to have to use Edge.

This isn't about the quality of Edge

The issue with this situation isn't related to if Edge is a good browser or not. I use Edge as my daily driver. The problem



Microsoft risks alienating users with its relentless push to make people use Edge.



with what Microsoft's doing is that it's forcing people to use the browser.

Microsoft says that there are certain experiences that aren't designed to be redirected. Why? Is a story from the News widget only going to work in Edge? When I search for "how to change my default browser" in the Taskbar, am I only going to see good search results in Edge? If Microsoft is going to let people set a default browser, that's what it should be, a default browser. In the event I set Chrome, Brave, Firefox, or anything else as my default browser, I should never see a link open in Edge.

Mozilla seems to agree with me. "People deserve choice. They should have the ability to simply and easily set defaults and their choice of default browser should be respected," said a spokesperson for the company to *The Verge*.

The developer of EdgeDeflector is more direct. They state, "these aren't the actions of an attentive company that cares about its product anymore. Microsoft isn't a good steward of the Windows operating system. They're prioritising ads, bundleware, and service subscriptions over their users' productivity."

This isn't new behaviour from Microsoft

I won't claim to be a legal expert, but I will highlight that Microsoft attempting to force people to use a browser isn't new. Decades ago it was Internet Explorer. Now, it's Edge. Microsoft seems hell-bent on getting people to use its browsers, even by force.

Forcing people to use a certain piece of software is always a bad look. I've seen people point out that Apple makes people use certain apps by default. So what? That's bad too. I'm not going to excuse a company for ignoring default app settings because I use their products.

Microsoft, Google, Apple, and all other companies should give people a choice. The situation with Microsoft is particularly infuriating because Windows claims that you can set different apps as your defaults. It then duly notes and ignores those settings.

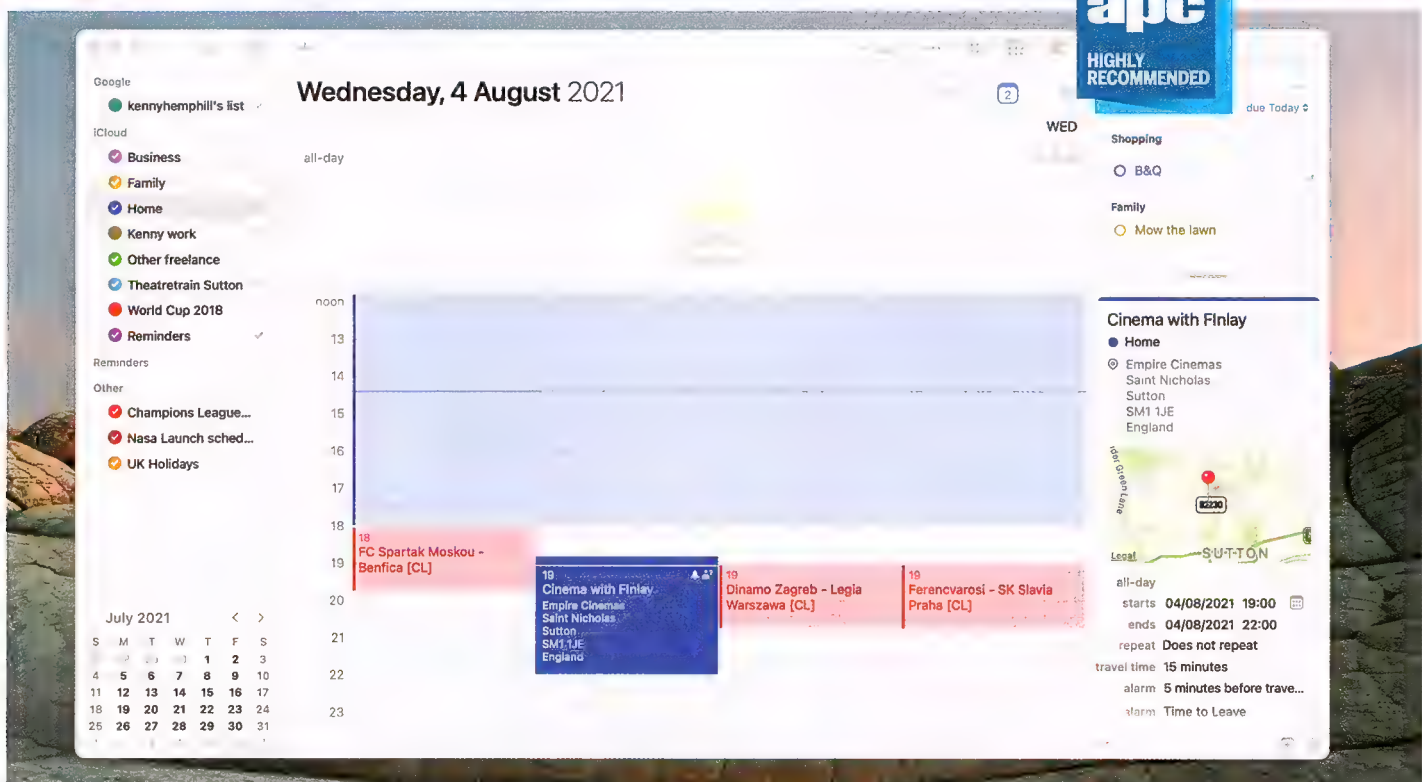
This isn't the way

Edge is a fine option in and of itself. Plenty of people I know have switched over to the Chromium version of Edge as their daily browser. But I guess that isn't good enough for Microsoft. Rather than organically converting people to its product, Microsoft appears determined to use the dominance of Windows to foist Edge on users so everyone and their grandma has to summon the browser when they click the weather widget on the Taskbar to check out the forecast. Spoiler alert, it's partly cloudy with a chance of Microsoft spitting on you and saying it's rain. ■

techradar

The source for
tech buying advice

techradar.com



MAC STORE & OTHER MAC APPS | macOS 10.12 or later | \$7.99 per month | busymac.com

BusyCal combines
calendar events and tasks.

BusyCal

Keep track of upcoming events and tasks with this big upgrade to an already popular calendar app.

There are so many calendar apps available for the Mac, not to mention the very good built-in Calendar, that attracting customers and standing out from the crowd is a tough job. The developers of BusyCal hope that this new version will do just that.

This version marks a change in the way BusyCal is priced. If you want to download it from the Mac App Store, you'll have to pay a subscription fee of \$7.99. Unlike BusyCal's competitor Fantastical, that fee only gets you the calendar app, not the associated contacts app. Alternatively, you can pay US\$49.99 as a one-time price and get 18 months of upgrades included, with the option to pay

a further US\$29.99 to extend the upgrade period.

BusyCal supports all the usual calendar services including iCloud, Google, Office 365, and WebDAV. It can also pull in tasks from iCloud Reminders. Tasks are integrated in the calendar views and also displayed in a task list in the right-hand sidebar. You can also view events and tasks in the BusyCal menu bar item. Like everything else in BusyCal, there are plenty of customisation options for how tasks are displayed. However, we found that those tasks added to Reminders' Groceries list didn't recognise the list name and so we couldn't filter it out.

As well as choosing how many days are displayed in a week or weeks in a month, you can choose font sizes, calendar colours and time formats. There's also a list view, that we found particularly useful for managing upcoming events and to-dos.

Like Fantastical, BusyCal displays a weather symbol as a forecast for upcoming days, as well as phases of the moon. BusyCal advertises 10 days' worth of forecasts, but in our tests, only eight were actually displayed.

As you would expect, BusyCal supports natural language input, and the ability to

drag and drop events to change their date or time, or their duration. A key element of BusyCal's display is its Info panel, which sits at the bottom of the right-hand sidebar. It can be a little cramped down there, so we were pleased to find an option to open it in a floating window where it can be expanded more.

There's support for travel time, allowing you to specify how much time to allow for travelling to an event, and you can choose whether to display alarms in BusyCal's Alarms window or in Notification Centre.

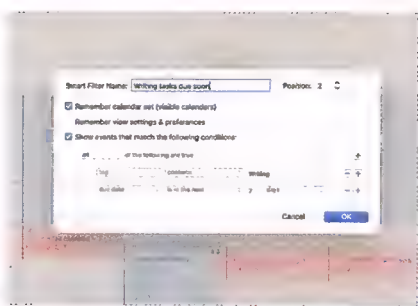
If you find yourself frequently searching for events or tasks, you'll appreciate the ability to add filters to search queries and save smart searches to use again.

There's plenty to admire about BusyCal, and the customisation options provide flexibility. To us, Fantastical's interface is cleaner and easier to navigate, but there's very little in it.

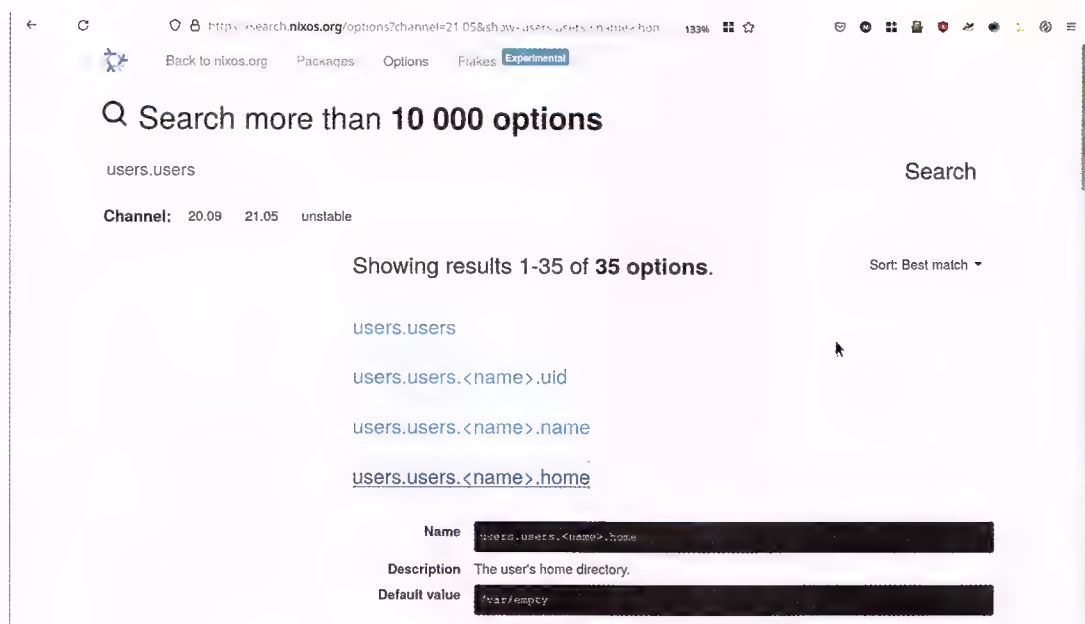
If Calendar isn't powerful or flexible enough for you, you'll find BusyCal has plenty to offer.

Kenny Hemphill

★★★★★



You can create very detailed filters and save them as smart searches to make it easy to find events and tasks.



NixOS is well documented, and it needs to be. Just look at the number of configuration options!

Linux | <https://nixos.org>

NixOS 21.05

A complete working distro created from a single configuration file sounds different, and Neil Bothwick discovers that it is.

Installing Linux is usually a matter of: boot from install media, run installer, make choices, drink a hot beverage, reboot computer and start configuring everything to your needs. NixOS turns this completely on its head.

The starting point for NixOS is a configuration file called `configuration.nix`. This is where you specify everything about how you want your system set up, from which partitions to install to and the filesystems to use, to the list of packages to install and the users to create. You have to create the partitioning yourself – Gentoo users will feel at home here – then run `nixos-generate-config` to scan your hardware and create a basic configuration, which you then edit.

Once you have done this, run `nixos-install` and sit back. After it has done its stuff, you should have a ready to use system. This is a lot more work than a traditional install, especially the first time, but it has the advantage of being reproducible, and this is where NixOS really finds its place.

If you want to set up a number of information kiosks or office desktops, all with the same configuration, you only need to create the configuration file once

then copy it to each of the computers and run the installer. Of course, you won't get it right first time, and even if your needs change, you can edit the configuration and run `nixos-rebuild` to apply your changes.

NixOS actually stores all files under `/nix`, so everything in the usual Linux hierarchy is a symlink to files in `/nix`. When you run `nixos-rebuild`, it create new files in `/nix` and updates the symlinks. The old files are still there and you can select previous incarnations from the boot menu, so you are safeguarded against an upgrade breaking something important.

This all sounds very clever, so what is the catch? It is that much of what you know about administering a Linux system does not apply. Want to export a filesystem by adding it to `/etc/exports`? You can't – that file is read-only, as is most of `/etc`. Instead, you add the relevant entries to `configuration.nix` and rebuild.

The problem is that, at least at first, everything takes three times as long to do because you have to search the documents and forums for the way to do it, because of the alien nature of NixOS. This is different from, say, Gentoo, where you have to edit files by hand, but it is all standard stuff. Thankfully, there is detailed documentation, with examples, of all the

configuration options, as well as a comprehensive package list, in a searchable format on the website.

When it comes to installing packages, the configuration file is not the only route. That installs packages globally, just like other package managers, but there is also the `nix-env` command that can be used to install software and make changes at the individual user level.

As a general-purpose desktop distro, it is hard to recommend NixOS to anyone but an enthusiast. However, as a means to create custom environments, repeatable across multiple machines, NixOS has a lot going for it.

Yes, you could do the same with Debian and a configuration manager like Ansible or Puppet, but there is a certain elegance to the NixOS way of doing things.

It is not so much a distro as a way of creating and installing your own custom distro.

Is this a good distro? That's a really complicated question. For most users the answer has to be no, but if you need to create multiple instances of the same, or a similar, system, and maintain them easily, it may be just what you are looking for. Just be prepared to put it some time getting it all set up first.

As a general-purpose desktop distro, it is hard to recommend NixOS to anyone but an enthusiast. However, as a means to create custom environments, repeatable across multiple machines, NixOS has a lot going for it.

A powerful, if somewhat specialised, distro concept. Be prepared to put some time into learning how to use it.

★★★★☆



LABS FEATURE

Intel 12th Generation buying guide

Chris Szewczyk shares tips, tricks and information to help you build the right Alder Lake system.

After a few years of ceding the high ground, Intel is back to being the market leader. 12th Generation CPUs have now reset the market. The move to a hybrid architecture featuring big and little cores along with their impressive IPC gains, plus the shift to a superior 10nm process (officially known as Intel 7), means there are huge gains in single-threaded and multi-threaded performance.

There are a number of other technological improvements and generational shifts including the debut of DDR5 memory and PCI Express 5.0 along with the introduction of a new socket – LGA 1700 and of course, new motherboards to support it all. The first

of these are based on the new Z690 chipset. We have a roundup of four tasty high-end options in the following pages.

There are many things to consider when planning your 12th Gen system. We'll go through everything you need to get your build up and running. There are cooling considerations, motherboards that offer DDR4 or DDR5, overclocking capabilities and more. Then there's the imminent release of more mainstream 12th Gen CPUs and more affordable motherboards in early 2022. That's before we start thinking about Windows 11, which is important to extract the best out of Alder Lake. There's a lot to unpack! Let's dive straight in.

The first of many 12th Gen CPUs

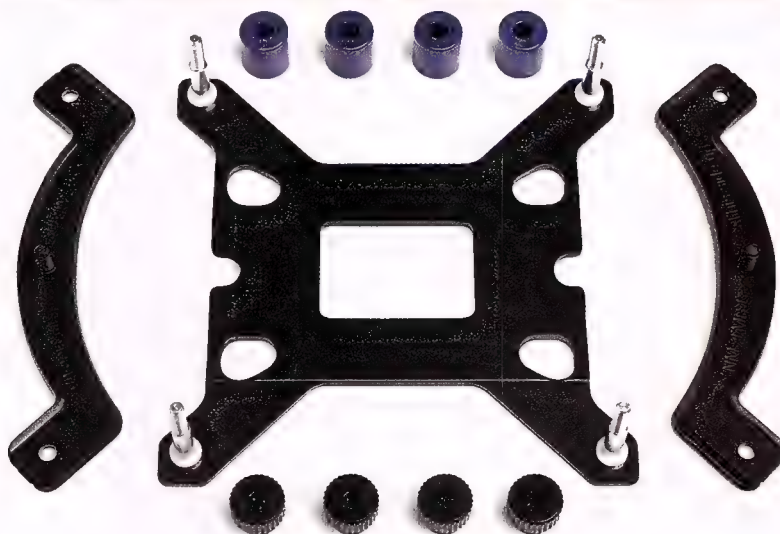
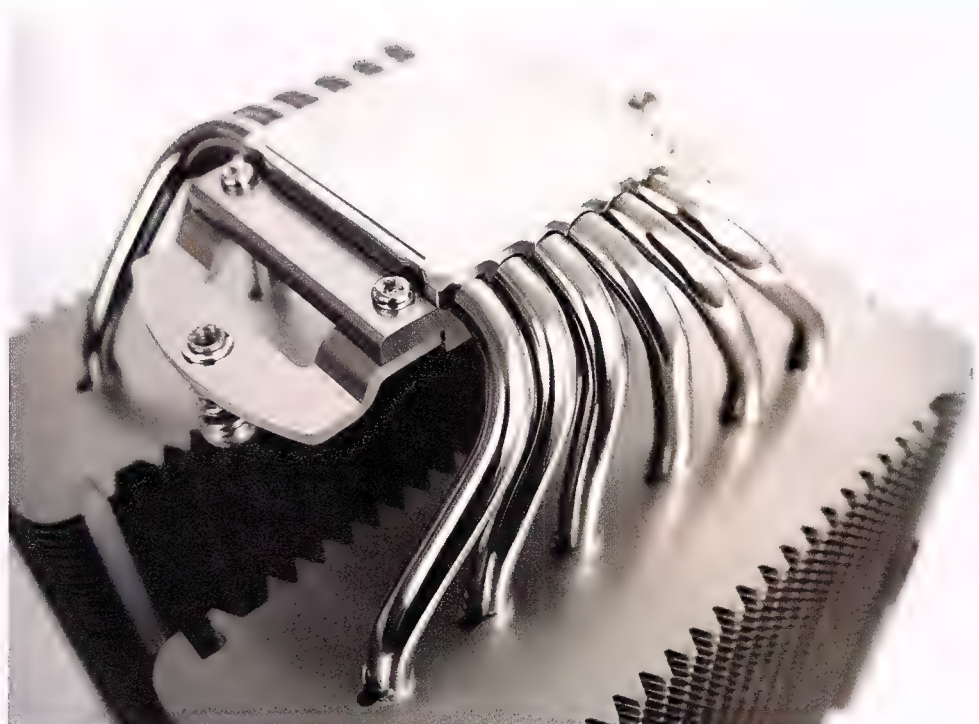
The first Alder Lake CPUs to launch are the 'K' CPUs, which feature an unlocked multiplier and higher power limits. They're the highest performing CPUs of their respective i9, i7 and i5 ranges and they're aimed at enthusiasts with deeper pockets. If you're interested in upgrading, don't feel like you need to drop big dollars right now, as beginning in early 2022 Intel will introduce non-K models and – as we move deeper into 2022 – lower tier i5, i3 and eventually Pentiums. There will be more affordable motherboards to suit too.

The yet-to-be released CPUs should offer a great blend of performance, value and power efficiency. Some of the cheaper models will end up omitting the E cores, so they'll lose some multi-threaded performance, but the big Golden Cove P cores are the ones that deliver single and lightly threaded performance, which is what's important for gamers. Affordable 6-core CPUs with or without E cores should be very potent gaming CPUs, much like the 11th Gen 11400 and 11500 models do. Keep an eye out for them in 2022.

Introducing feature packed, but very expensive Z690 motherboards

This issue features our Z690 roundup. As is usually the case when a new platform appears, we tend to analyse the mid-high-end models in order to show off the best features that the platform has to offer. Most of the mid-tier and higher boards are very well built and premium boards include features such as Thunderbolt 4, monstrous VRM designs, and greater expansion support thanks to more chipset PCIe lanes. The latter is particularly important for users who plan to use a number of M.2 drives. The bad news is that a big step up in features is joined by a big step up in expense compared to Z590 boards, which in turn were more expensive than Z490 boards.

The expense of even entry level Z690 boards is likely to hamper adoption. Luckily for mainstream buyers, Z690 is just the first of several 12th Gen supporting chipsets to come in 2022. B660 and H670 boards are expected to offer memory overclocking, which was introduced with B560. This greatly enhances their appeal. A user with a single GPU, a couple of M.2 drives and a SATA drive or two should find a B660 system will lose nothing in performance to a Z690 system. Then there's the benefit of much better value for money than that offered by Z690. Some features such as PCIe 5.0 support are yet to be confirmed.



Top: While we expect mid- and low-tier 12th Gen CPUs to run relatively cool – don't skimp on quality cooling if you're planning on building around the top-tier 12900K. *APC* recommends a 240mm AIO or high-end air cooler.

Above: With 12th Gen comes the new 600-series motherboards and new LGA 1700 socket. Be sure the cooler you buy is compatible. It may be possible to buy an LGA 1700 adaptor for LGA 1200 coolers, check with the manufacturer.

12th Gen CPUs retain support for DDR4 memory and there are many affordable Z690 motherboards that support DDR4. Obviously, this means you can reuse your current DDR4 memory in a new Z690 board, negating the need to buy expensive new DDR5 memory. There's also the fact that DDR4 doesn't lose much in the way of performance compared to DDR5. High quality DDR4 has lower latency than DDR5 so in applications that benefit from low latency, such as games, DDR4 is a perfectly viable option. Though strictly a rumour for now, it's looking likely that 13th generation CPUs due in late 2022 will continue to support DDR4, so an investment in a good DDR4 kit isn't a dead-end path yet.

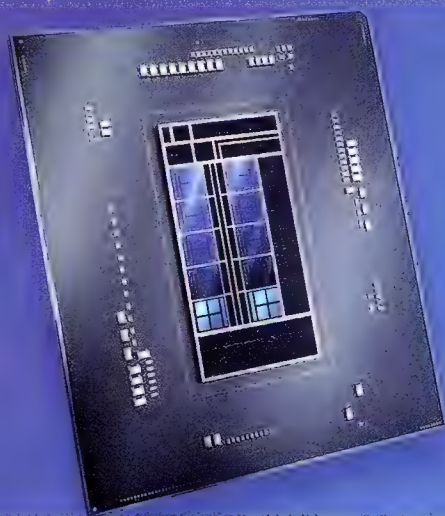
It's also likely that 13th Gen CPUs will be supported by 600-series motherboards after a BIOS update. A decent 600 series motherboard is likely

to remain relevant for a few years to come. A system with PCIe 5.0, a future set of increasingly faster and lower latency DDR5 memory plus a 12th or 13th Gen processor is surely likely to remain a very fast system in 2024 and beyond. Add in features like Wi-Fi 6 or 6E, 2.5G or faster LAN and USB 3.2 Gen 2 and Thunderbolt 4 and you'll have a system that's up to date for a few years to come.

Introducing DDR5 memory. Is it worth the cost?

12th Generation CPUs introduce support for the brand new DDR5 memory standard. The first wave of kits look very good – on paper at least. DDR5 speeds begin at 4800MHz, with kits at 6400MHz already available. DDR5 essentially doubles memory bandwidth and density of DDR4 while running at a lower voltage with better efficiency.





Here's Intel's new Razer Blade 12900K CPU. While still built on the traditional monolithic process (meaning it's all packed onto a single die), 12th Gen incorporates enough advanced tech to make it extremely competitive.

Power-management is now controlled by the modules themselves and there's also a limited form of ECC, though it's not the same as the ECC you'll find on enterprise class modules. There's XMP 3.0 support which introduces user programmable profiles for the first time. Tweakers will really appreciate that.

But DDR5 faces two significant headwinds, the first of these is its expense. Steep launch pricing is to be expected with any new technology but given supply chain issues and scarcity, DDR5 is looking like poor value as we write this. A decent DDR5-5200 C38 kit (which is only a step above the base DDR5-4800MHz JEDEC spec) costs well over \$500 for a 2x16GB kit. That compares to a quality DDR4-3600 C16 kit that's half that price at under \$300. It's a big ask given that in the coming years, a DDR5-5200 kit will end up being seen as slow, much like a DDR4-2400 or 2666 kit is by DDR4 standards.

That brings us to the second point. Latency. Using the aforementioned kits

as an example, The DDR5-5200 C38 kit would roughly equate to the latency of a DDR4-2600 C19 kit. Compare that to the DDR4-3600 C16 kit and it's clear that DDR5 has some way to go before it reaches maturity. Of course, latency isn't the be all and end all. The raw bandwidth of DDR5 will see it win out in many applications but as it stands now, the expense of DDR5 relegates it to enthusiasts only. If you've got a fast DDR4-3600 kit, you can run the memory controller in Gear 1 mode, delivering strong performance while saving a good chunk of money.

By the time AMD's Zen 4 and Intel's 13th Gen CPUs roll around, we should be past the worst of the pandemic supply-and-demand crunch. DDR5 speeds will be faster, with lower latency and hopefully they'll be a lot cheaper too. Spend big on DDR5 right now only if you're an enthusiast who demands the best gear for a high spec system.

We plan to further examine DDR5 in our next issue, including a roundup of

popular kits from the leading brands. Stay tuned for that!

Introducing PCI Express 5.0. Watch out for it in 2022

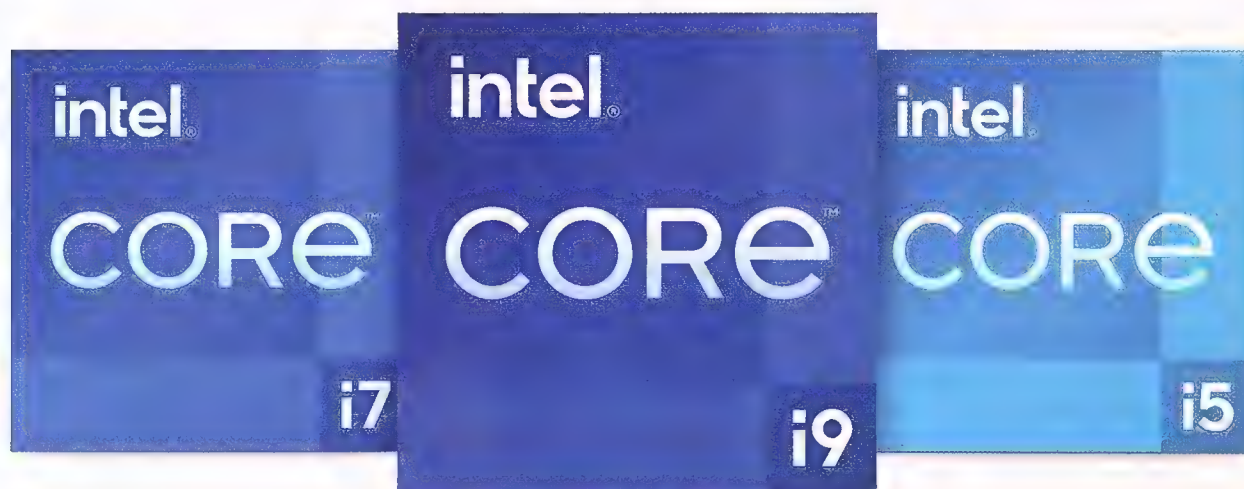
Alder Lake introduces PCI Express 5.0. It offers double the bandwidth of Gen 4, moving from 16GT/s per PCIe 4.0 lane to 32GT/s for a PCIe 5.0 lane. Intel's adoption of PCIe 5.0 means it's moved from PCIe 3.0 to PCIe 4.0 to PCIe 5.0 in the space of just one year.

PCIe 5.0 doesn't have any supporting devices right now, but look for that to change in 2022. The first devices to support PCIe 5.0 will be NVMe SSDs. Think sequential transfer rates of 14GB/s! The first drives will likely be hot and expensive, but such is the cooling offered by many Z690 boards (check out the M.2 cooling of the Aorus Master), throttling shouldn't be an issue.

Note that the primary M.2 slots of Z690 motherboards only support PCIe 4.0, so to get PCIe 5.0 speeds, you'll need to buy an add-in card, though some high-end boards have bundled cards. This will mean the boards that have dual PCIe 5.0 slots will be required to run at 8x/8x. Given that a PCIe 5.0 8x slot is equal in bandwidth to that of a PCIe 4.0 16x slot, this will present little, if any disadvantage for a future PCIe 5.0 GPU. Speaking of GPUs, it's likely, though unconfirmed, that future Nvidia Ada Lovelace and AMD RDNA3 GPUs will support PCIe 5.0 when they launch in late 2022.

Do not skimp on your cooling!

12th Gen CPUs, while delivering very good performance, do not offer good power efficiency compared to what's offered by AMD. A power-hungry CPU means it pumps out a lot of heat, and you'll need very good cooling to dissipate it, at least you do for the 12900K. The 12600K and future non-K CPUs will fare



Above: Despite having a completely new architecture, Intel chose to retain the 'Core' branding.



Left: The 12th Gen launch began with high-end Z690 motherboards (reviewed across the following pages). **Below left:** DDR5 memory remains a question as availability is currently poor, and performance (for the initial speeds) compared to DDR4 is marginal.

temperatures, power consumption and efficiency, which are already the Achilles heel of 12th Gen under default operation. Our 12900K sample can hit 5.1GHz on all P cores at 1.45V but applying an all core load sees temperatures head into the 90s even with a 360mm AIO! 12900K OC is so limited, we suggest that the K SKUs don't really offer anything above the non-K CPUs.

Closing thoughts

To get the best out of your 12th Gen system, it's recommended that you upgrade to Windows 11. Intel's on-die Thread Director and Windows 11's hybrid architecture awareness means it's the best way to make sure that threads are assigned to the appropriate cores. Windows 10 isn't bad, but its not as developed as Windows 11 at this point in time, and it likely never will be.

We're all tired of the pandemic and its flow on effects. Ongoing supply chain issues and shortages mean that the prices of motherboards and DDR5 memory are a lot higher than we'd like. The CPUs aren't badly priced – if you need to upgrade, by all means go for it, but waiting until more affordable CPUs and motherboards are available will deliver much bang for your buck.

Look for 12th Gen laptops at CES. Intel says that it expects Alder Lake to scale all the way down to ultra-portable devices, so it will be interesting to see what laptop manufacturers will have to offer as we move into 2022.

This concludes our 12th Gen guide. Honestly, we could fill this whole issue with 12th Gen talking points! But we're still very early in the life of the platform and our Z690 motherboard roundup is just a part of it. 2022 will see many new CPUs, motherboards and chipsets, to say nothing of what AMD has up its sleeve. As always, APC will be all over all things 12th Gen. Things are just getting started!

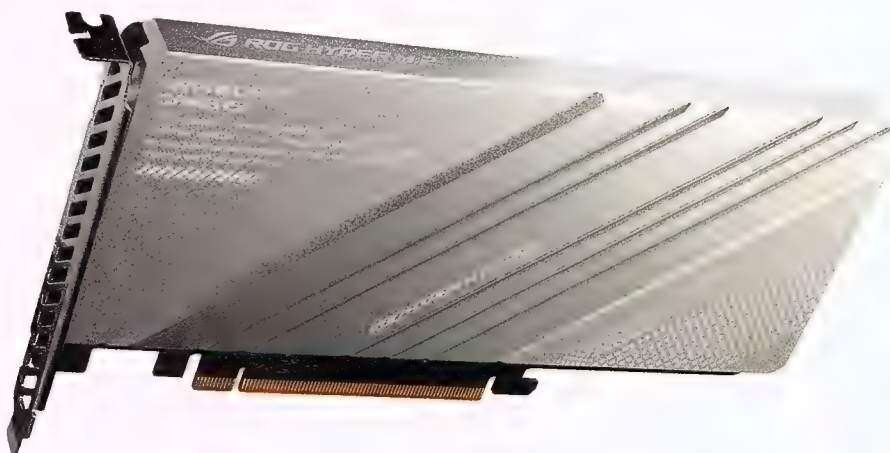
better. The introduction of a new socket means that existing LGA 1200 coolers aren't compatible without an adapter. These are available from retailers or manufacturers directly. It's very important to make sure that the cooler you buy supports LGA 1700. That's the kind of oversight that's surely frustrated a few buyers.

If you're buying a 12900K, we'd suggest a 240mm AIO or high-end air cooler at a minimum, otherwise you'll run into thermal throttling issues under an all core load. The 12600K fares a lot better, but it still requires a capable cooling solution. SFF fans are better off waiting for the 65W CPUs in 2022. If you are experiencing high temperatures with a K CPU, you can tune the power limits in the BIOS. Try lowering the PL2 a few watts, which will cost a little performance, but you'll get lower temperatures while keeping most, if not all, of the single threaded turbo boosting.

Overclocking – don't bother with the 12900K

12th Gen K processors can be overclocked, but the question is, is it worth it? The answer depends on the CPU in question. For the 12900K, the

answer is no. For the 12700K the answer is maybe and for the 12600K, the answer is somewhere between maybe and yes. The limiting factor is cooling. Even under default operation, 12th Generation CPUs can run very hot, and given the mature performance of Intel's Turbo boosting functionality, OC gains are very limited. Overclocking can deliver single digit gains or higher under multi-threaded loads, but at the expense of shocking



Above: As we saw with previous PCIe generations, expect PCIe 5.0 expansion cards to add more M.2 SSD capacity.



\$1,049 | www.asrock.com

Asrock Z690 Taichi

This Taichi is all grown up.

Over the years, Asrock's Taichi family has gone from a solid mid-range brand to a genuine high-end product. It's got almost all the features you'd expect from a premium motherboard but without the high-cost extras that separate a board at this price from the crazily priced flagships.

Looks are subjective, but for us the cyberpunk theme, with splashes of copper colouring, looks amazing. There's also a small cog above the I/O that actually moves! If you're a fan of Razer products, Asrock offers a Razer-themed Taichi for easy integration into the Chroma ecosystem.

The Taichi features seven SATA ports, one of which (along with a single USB port) is independent from the others. Asrock says this can function as a protection from malware. Other key features include dual PCIe 5.0 slots and three M.2 slots, though one of them supports PCIe 3.0 x2 only. The Taichi is a little lacking compared to some of the other boards in the roundup when it comes to storage options.

Like most high-end Z690 boards, the Asrock has a very strong VRM solution. With its 20-phase 105A stages, even a heavily overclocked 12900K won't stress it. The VRM heatsink has a little less

Specifications

LGA 1700 socket; 3x M.2; 6x SATA; 2x Thunderbolt 4 Type-C; Up to 1x USB 3.2 Gen2x2, 2x USB 3.2 Gen 2, 9x USB 3.1 Gen 1, 3x USB 2.0; 1x HDMI; Killer Wi-Fi 6E; Killer E3100G 2.5G and Intel I219V 1G LAN; Realtek ALC1220 7.1 Channel HD Audio; ATX Form Factor.

surface area than some, but do note there is an internal fan. Luckily it runs at very low speed and we'll admit we didn't even know it was there until after disassembling the system. 20 minutes of Cinebench looping delivered a 53c VRM temp. That's outstanding.

The rear I/O features dual Thunderbolt 4 ports along with two 3.2 Gen 2 ports and four 3.2 Gen 1 ports. There's a PCI bracket if you wish to add a couple of USB 2.0 ports via a header. Networking duties are handled by Killer E3100G 2.5G and AX1675 Wi-Fi 6E controllers. They are joined by an Intel I219V Gigabit controller. Would a typical user prefer a single 5 or 10G Lan controller over 2.5G and 1G? Perhaps. The rest of the I/O panel is fairly standard, with HDMI and ALC 1220 driven audio. Asrock deserves praise for including a good quality ESS Sabre 9218 DAC; that's a clear step up from basic onboard audio.

When it comes to performance, the Taichi performed as expected. The motherboards of this generation appear

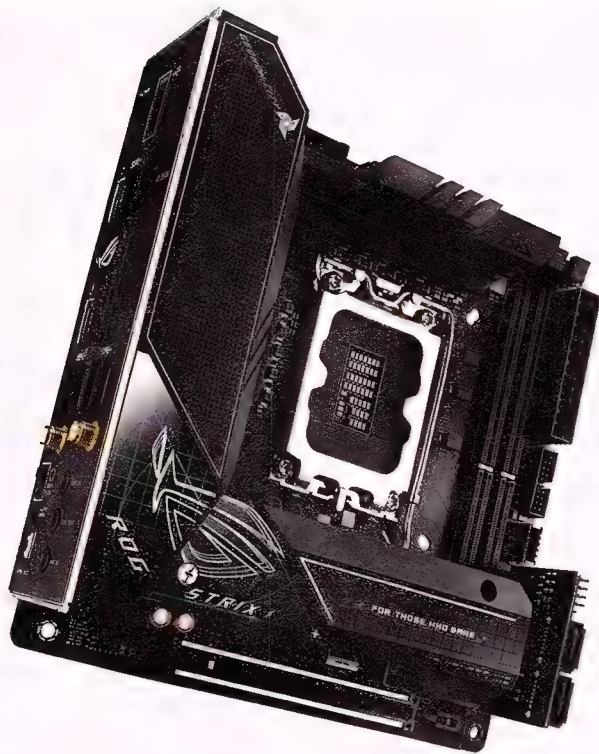
to be performing very closely to one another, likely due to Intel's new turbo definitions which means the CPU clocks don't vary a lot between boards. Notably, the Taichi often topped the gaming tests. Though the differences are all but insignificant, it's better to lead the pack than trail it. It was also the best memory overclocking board of the bunch, though surely there's a lot of BIOS maturation to come for all Z690 boards.

The Asrock Z690 Taichi is a really premium product. It's got dual Thunderbolt 4 ports, a quality VRM and audio solution, support for DDR4-6400 memory and it's gorgeous too. Its problem is its price. It's up against tough competition from the likes of the Aorus Master, but with most electronics right now, component shortages make value for money analysis a week-to-week proposition. In time the Taichi may end up offering great value for money to go along with its looks, solid performance and apart from its below par M.2 count, its strong feature list too.

The Asrock Z690 Taichi is a really premium product. It's got dual Thunderbolt 4 ports, a quality VRM and audio solution, support for DDR4-6400 memory and it's gorgeous too.

This isn't the Taichi you remember. It's better! But the sticker shock will drive buyers towards something cheaper.

★★★★☆



\$649 | www.asus.com

Asus ROG Strix Z690-I Gaming Wi-Fi

Pushing the limits of ITX.

As you may have guessed, the Asus ROG Strix Z690-I Gaming Wi-Fi is a Mini-ITX offering, and as one of the few high-end Z690 ITX boards, it's a board that will garner a lot of attention from fans of small form factor computing.

Mini-ITX boards, with their limited PCB space, tend to lack controllers and particularly M.2 slots. Asus has put a huge amount of effort into the design of the Z690-I with double stacked M.2 slots complete with a separate audio PCB to go along with a daughter board that contains four SATA ports and the front panel headers. It sure is a 3D motherboard! The rear mounted M.2 slots common to many ITX boards can lead to overheating so we're pleased that Asus has gone down this path.

The Asus incorporates a 10+1-Phase 105A VRM into its compact design. The larger socket takes away some area meaning the heatsinks are small relative to ATX Z690 boards. After 15 minutes of Cinebench looping, we saw a peak VRM temperature of 69 degrees. That's warm, but still fine. Not everyone is running a 12900K. This, along with its single 8-pin power connector, leads us to suggest that the Z690-I is better suited to an i7 or i5 processor.

The rear I/O is very good for an ITX

Specifications

LGA 1700 socket; 2x M.2; 4x SATA; 2x Thunderbolt 4 Type-C; Up to 1x USB 3.2 Gen2x2, 2x USB 3.2 Gen 2, 5x USB 3.1 Gen 1, 4x USB 2.0; 1x HDMI 2.1; Intel Wi-Fi 6E; Intel I225V 2.5G LAN; Realtek ALC 4080 7.1 Channel HD Audio; Mini-ITX Form Factor.

offering. The highlight is the two Thunderbolt 4 Type-C ports. These are joined by two USB 3.2 Gen2, three 3.1 Gen1 and two 2.0 ports. You get Wi-Fi 6E and 2.5G Ethernet. Add to that BIOS flashback and CMOS clear plus HDMI 2.1 and you've got a set of ports that aren't out of place on boards costing a lot more. The MSI Unify and Aorus Master notably lack those Thunderbolt ports for example.

The little Asus performed as expected in the CPU and system benchmarks. However, its gaming performance was a little inconsistent, often trailing the other boards in situations where the load is on the GPU. There's nothing to worry about at all, but it's hardly top-tier. The Asus was able to run our overclocked DDR5-6400 G.Skill memory; dual slot ITX boards are generally good at memory overclocking so this is a good sign of a mature early BIOS.

ITX boards fill a niche and directly comparing the Asus ROG Strix Z690-I to more expensive ATX boards is a

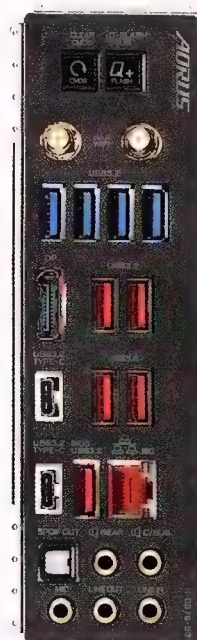
little misleading. But, if you take away the M.2 slot limitation, the Asus is almost as feature rich as the more expensive boards. Those dual Thunderbolt 4 ports will really come into their own in the years ahead. You get plenty of USB and solid networking too. We also love the engineering. It's not easy to devote resources to this kind of innovative design.

\$649 would be top-end motherboard pricing three years ago, but here we are in the midst of a pandemic and \$649 is regarded as good value. The little Asus isn't perfect but we're sure that, like most boards, BIOS releases will iron out the platforms' niggles. If you're after a feature rich Mini-ITX board that compromises as little as is reasonably possible, then there's no better Z690 ITX board. Pair one with an i5-12600K and you'll have a potent little SFF gaming system on your hands.

The little Asus performed as expected in the CPU and system benchmarks. However, its gaming performance was a little inconsistent, often trailing the other boards in situations where the load is on the GPU.

The Little Strix Z690-I punches above its weight though its best to pair it with i5 or i7 processors.

★★★★★



\$899 | www.aorus.com

Gigabyte Z690 Aorus Master

One of the most feature packed of all Z690 boards.

Gigabyte's Aorus Master, like all other Z690 motherboards, are more expensive than their predecessors. If you don't mind paying the price, the Aorus Master will deliver a whole lot of motherboard and one that's still priced well below what the top-tier flagship boards cost.

Boards at this price level are expected to feature a strong VRM and the Aorus is about as good as it gets. With its 19 phase 105A design, it will sail through heavily overclocked 12900K loads with ease. We've always liked Gigabyte's finned heatsink design, which manages to combine function and form. There's simply no substitute for surface area when it comes to heat dissipation. We recorded a temperature of 49 degrees after looping Cinebench for 20 minutes – that's a very good result.

The board has plenty of high-end features. There are five M.2 slots, with the primary one deserving particular attention. A drive in this slot will be cooled by a very large heatsink that dwarfs anything offered by SSD manufacturers. The other slots are covered by the large integrated heatsink though it's important not to forget good case airflow as the entire

Specifications

LGA 1700 socket; 5x M.2; 6x SATA; Up to 2x USB 3.2 Gen2x2, 6x USB 3.2 Gen 2, 8x USB 3.1 Gen 1, 4x USB 2.0; 1x DP; Intel Wi-Fi 6E; Aquantia 10G LAN; Realtek ALC 1220-VB 7.1 Channel HD Audio; E-ATX Form Factor.

area will be affected by a hot-running graphics card.

Apart from the Thunderbolt 4 of the Taichi and Asus ITX, The Aorus Master's rear I/O includes almost everything you'd ever want with eleven USB ports including a USB 3.2 Gen 2x2 Type-C port. There's AX510 Wi-Fi 6E and the very welcome Aquantia 10Gb LAN. If you're one of those users who have SSDs connected to your network, you'll love that. You get a single DisplayPort for use with Intel's Xe graphics, a welcome Q-Flash BIOS update button, and gold-plated audio ports. The Master's audio deserves praise. Similar to its Z590 predecessor, the Z690 Master features the Realtek ALC1220-VB codec and ESS ES9118 Sabre DAC with all the trimmings. It's about as good as motherboard audio gets short of a decent discrete solution.

When it comes to performance the Aorus performed pretty much the same as all the other boards in the test with no outlier results to speak of. It was the weakest board of the test when it came

to our DDR5-6400 test, which wasn't stable. We feel that the Master is an update or two away from performing at its best. Do bear in mind that we're dealing with a brand-new platform, and it's expected to mature over time.

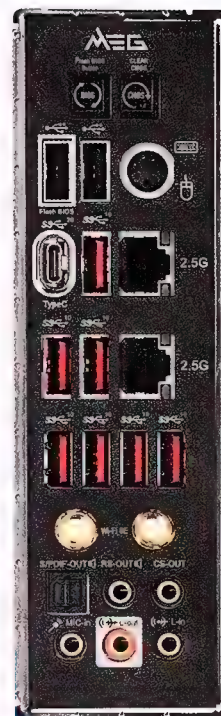
The Aorus Master hits a great balance of excellent features without the laughable prices of the flagships. You get a mega VRM with cooling to match, five M.2 slots, 10G LAN plus Wi-Fi 6E and a very good audio solution. About the only thing missing is Thunderbolt 4 support, though with all the other USB connectivity onboard, it's likely you can get away without having that right now.

At \$899 the asking price is steep, but that's a trait shared by almost all other Z690 boards. If you're going to go all out on a 12th Gen build, the Aorus Master is worthy of consideration. It's got a strong feature list, lacking only Thunderbolt 4, but there are plenty of other little touches that make up for it. After a BIOS update or two we think it can really shine.

The Aorus Master hits a great balance of excellent features without the laughable prices of the flagships. You get a mega VRM with cooling to match, five M.2 slots, 10G LAN plus Wi-Fi 6E and a very good audio solution.

It's difficult to say a \$900 motherboard offers value for money, but relative to its competitors, it definitely does.

★★★★☆



\$899 | www.msi.com

MSI MEG Z690 Unify

Discrete and subtle. Yes, it can be done.

The MSI MEG Z690 Unify sits near the top of MSI's motherboard range – the MEG name is reserved for MSI's top of the line boards. It will be joined by the Ace and the flagship Godlike at a later date. MSI has designed the Unify with overclocking in mind and unlike most gaming boards these days, the Unify omits all RGB lighting in favour of an all-black, functional and discrete design. Sometimes, less is more.

A board designed for overclocking has to have a strong VRM and cooling solution and as is the case with the Aorus and Asrock boards, it certainly does. A 19-phase digital design with 105A stages means there's ample power on tap no matter if you're using air, water, or ln2 cooling. The heatsinks are very heavy, though they don't have the surface area of a finned design. This shows in the VRM temperature test where the MSI topped out at perfectly acceptable 55c, though still the second highest result of the four tested boards apart from the tiny ITX Asus.

The board features five M.2 slots. It's a testament to the improved Z690 chipset. More lanes and a faster chipset link mean more connectivity. The topmost slot features an enlarged heatsink. The board comes with six SATA ports, with two of

Specifications

LGA 1700 socket; 5x M.2; 6x SATA; Up to 2x USB 3.2 Gen2x2, 7x USB 3.2 Gen 2, 4x USB 3.1 Gen 1, 6x USB 2.0; Intel Wi-Fi 6E; 2x Intel I225V 2.5G LAN; Realtek ALC 4080 7.1 Channel HD Audio; ATX Form Factor.

them coming via an Asmedia controller.

The rear I/O is impressive though unlike the Asrock, it lacks Thunderbolt 4 ports. You get a total of ten USB ports consisting of a Type-C USB 3.2 Gen2x2 port, seven USB 3.2 Gen 2 ports and two USB 2.0 ports. The Realtek ALC 4080 codec powers the standard set of audio ports, which includes S/PDIF. The MSI's networking setup is strong, with dual Intel I225-V 2.5 GbE plus Intel's AX210 Wi-Fi 6E controllers. There's a BIOS flashback button and a PS/2 port for the old schoolers.

As we've been saying throughout the roundup, these boards are all performing very similarly to one another. The MSI also proved to be a strong memory overclocker, with a first-time boot of DDR5-6400 at 1.35V working without issue. Good memory OC at this early stage is a good sign of BIOS maturity, and important for an overclocking-focused board. We also noted that the Unify pulled 364W of power during our VRM stress test. This is 27w more than the MSI Carbon Wi-Fi

that we used for our 12900K review. It's a thirsty board!

The MSI is somewhat unique with its RGB-less design. Though you can turn off RGB on other boards, the all black aesthetic will definitely appeal to many users. It's got a strong VRM, lots of USB and M.2 slots plus very good networking capabilities. Notably, its memory overclocking was second only to the Asrock, making the Unify a good choice if you're looking to grab some high-speed memory now, or in the future. We're sure there's more to come from Intel and MSI on that front as DDR5 technology matures.

The Unify is a very strong board that's very well built. At \$899 we'd like to see Thunderbolt 4 or a faster NIC, but not everyone weighs such things that heavily. If you're an overclocker, the Unify's connectivity, lovely design and overclocking capability will likely make it a very strong contender. If you go with the Unify, you won't be disappointed. Like all Z690 boards though, its price will lead many towards cheaper options.

We also noted that the Unify pulled 364W of power during our VRM stress test. This is 27w more than the MSI Carbon Wi-Fi that we used for our 12900K review. It's a thirsty board!

The MSI Unify is a solid offering, but the competition is fierce.

★★★★★

THE NUMBERS

Intel 600-series motherboard benchmark results

	Handbrake 1.4.2 - Video conversion 4K to 1080p FPS	Cinebench R23 - Rendering - Multi thread Score	Cinebench R23 - Rendering - Single thread Score	Blender 2.92 Classroom - Render Time (seconds) Lower is better	7Zip 21.03 - File Compression - Billion Instructions per second	POV-Ray 3.8.0 Ray Tracing - Pixels Per Second
Gigabyte Z690 Aorus Master	83.4	27,235	1,990	250	140.34	9,890
Asrock Z690 Taichi	83.4	27,010	1,978	251	140.54	9,890
Asus ROG Strix Z690I Gaming Wi-Fi	83.7	27,257	1,990	250	140.59	10,005
MSI MEG Z690 Unify	82.8	26,989	2,013	253	139.57	9,917

	CPU-Z - Multi Thread Score	CPU-Z - Single Thread Score	Peak System Power Consumption - Wall Draw (watts)	Geekbench 5.4.2 - Multi Thread Score	Geekbench 5.4.2 - Single Thread Score	PCMark 10 - Extended Score
Gigabyte Z690 Aorus Master	11,391	815	353	19,182	2,000	12,924
Asrock Z690 Taichi	11,463	821	350	19,234	1,994	13,049
Asus ROG Strix Z690I Gaming Wi-Fi	11,325	816	365	19,162	2,009	12,713
MSI MEG Z690 Unify	11,381	817	364	18,948	2,000	12,707

	AS SSD - Read Score	AS SSD - Write Score	3DMark TimeSpy Extreme - Overall score	3DMark TimeSpy Extreme - CPU score	Metro: Exodus Enhanced Edition - 1080p, Ultra, DX12, Avg FPS	Metro: Exodus Enhanced Edition - 1080p, Ultra, DX12, Min FPS
Gigabyte Z690 Aorus Master	4,521	6,907	10,181	9,375	133.6	70.1
Asrock Z690 Taichi	4,505	7,136	10,137	9,375	134.3	71.5
Asus ROG Strix Z690I Gaming Wi-Fi	4,389	7,187	10,159	9,391	131.6	70.4
MSI MEG Z690 Unify	4,512	6,783	10,177	9,164	133.0	69.8

	Civilization VI - 1080p, Ultra, DX12, Avg FPS	Civilization VI - 1080p, Ultra, DX12, Min FPS	Civilization VI - 1080p, Ultra, DX12, AI Turn Time	Ghost Recon: Breakpoint - 1080p, Low, Avg FPS	Middle Earth: Shadow Of War - 1080p, Lowest Preset, Avg FPS
Gigabyte Z690 Aorus Master	296	207	7.37	240	364
Asrock Z690 Taichi	298	211	7.37	242	372
Asus ROG Strix Z690I Gaming Wi-Fi	294	201	7.42	235	370
MSI MEG Z690 Unify	295	207	7.29	239	366

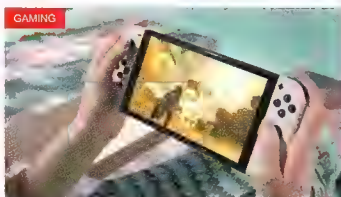
TRENDING [Sky Glass](#) [Windows 11](#) [Disney Plus Day](#) [iPhone 13 review](#) [Google Pixel 6](#)

WEARABLES



5 reasons why I'm upgrading to the Apple Watch Series 7

It may not be the new design I expected but there's lots of reasons why I'm upgrading to the new Apple Watch Series 7



Nintendo Switch OLED gamers will be thrilled to discover this hidden upgrade

A Nintendo Switch OLED dock discovery points to something very, very exciting

BY ROBERT JONES • LAST UPDATED 5 DAYS AGO



Netflix's Squid Game is a battle royale version of the Saw films and I was not prepared for it

No wonder the South Korean series is set to become Netflix's most popular show to date

BY MATTHEW FORDE • LAST UPDATED 6 DAYS AGO



Video: this Smart Life golf challenge proves tech can improve my golf... but it can't work miracles, sadly

Who takes a rangefinder AND a GPS watch to a 9-hole golf challenge? T3 of course...

BY DAVID USHER • LAST UPDATED 8 DAYS AGO



Nintendo Switch OLED has a fantastic hidden upgrade



Cord vs Cordless Drills: what's best for your next DIY project?



Try these mini challenges for mental wellbeing, says brain scientist

Want more T3?

www.t3.com/au

AND HERE

Quantum computers are here...

AND HERE

AND HERE...



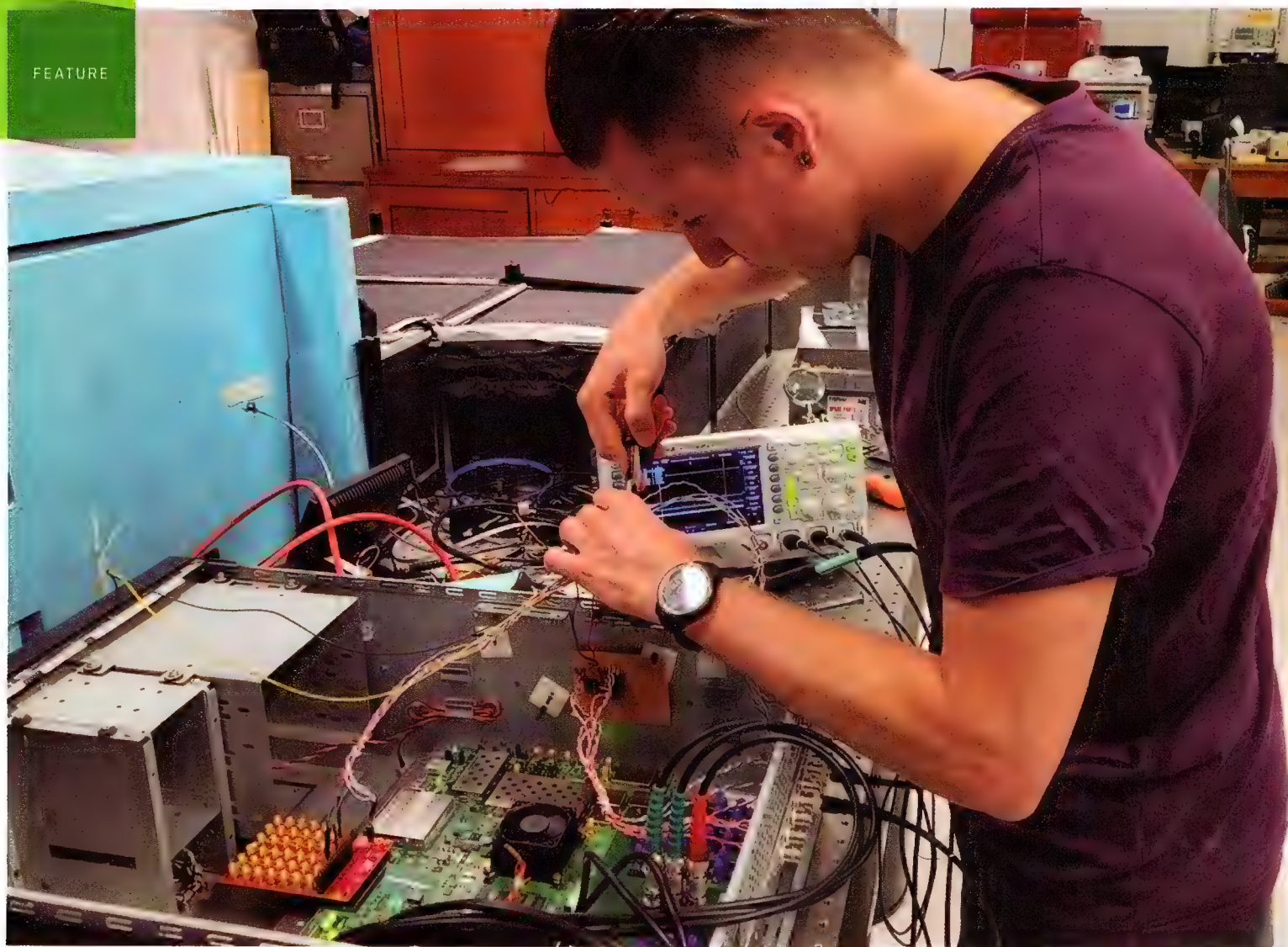
The first quantum computers are being delivered to researchers and supercomputing centres. What will we do with them?

Ian Evenden finds out.

Quantum computing is one of those technologies that seems forever just over the horizon, much like the flying car or an iPhone that lasts all day on a single charge. Developments come and go, announcements are made, each sounding crazier than the last, but tangible benefits never seem to appear.

Physicist Richard Feynman, one of the first to conceive of a quantum computer, due to his interest in the relationship between physics and computation, often has a quote attributed to him – it's possibly apocryphal, but most certainly apt: "If you think you understand quantum mechanics, then you don't." The same is almost certainly true of quantum computing, where there are so many new terms and variables to consider, it seems impossible for a single human brain to hold them all. The fact that so many of them sound like science fiction is perhaps part of the discipline's appeal.

Having multiple approaches to solving the same problem certainly keeps the scene lively, and we envisage endless debates between scientists along the lines of whether Intel or AMD is best, and whether the cryogenic cooling plant really needs all that RGB. It also means that we've had a solid run of news announcements and tech demonstrations recently, as work held up by the pandemic begins to bear fruit.



A member of the Quantum Brilliance team doing something we're quite familiar with.

Bending thermodynamics probably...

Take time crystals. Yes, really. Despite sounding like something the Emperor Zog is searching for, protected by a plucky band of heroes including at least four kids and a puppet, a time crystal is a real thing: Google has made them using a quantum computer.

Emperor Zog can relax, however. A time crystal has possible practical uses as quantum memory or as a sensitive detector of quantum fields but isn't going to destroy the universe. Imagine a system of particles in its lowest energy state, meaning it cannot lose any more energy to its environment, yet remaining in motion. The particles cannot come to rest because they are already in their quantum ground state, and usually would be still, but remain moving. It sounds like perpetual motion does an end-run around the second law of thermodynamics, but it has been demonstrated by a team from Stanford, MIT, and Google using Google's Sycamore quantum processor.

Being in motion means it can flip between two states without losing energy, in theory doing this forever like a pendulum that will never stop swinging. MIT physicist Frank Wilczek wasn't involved in the work, but he hypothesised the existence of time

crystals back in 2012. "They can be sensitive probes of certain kinds of external fields, so they will give us, in principle, new kinds of exquisitely sensitive devices," he told *New Scientist*.

The other thing about quantum computing is that there are so many approaches. It's as if the early pioneers of our CPUs couldn't agree on a material to make transistors out of, and instead split into factions, one using silicon, another using luminiferous ether, and another using cheese. They all work, and arguments persist about which is the best way of creating one.

Google's Sycamore computer is an example of one kind of processor, the superconducting quantum processor. This is the sort of technology most commonly associated with quantum computers and requires cooling systems that chill them to within a fraction of absolute zero. Under these conditions, the qubits – the quantum equivalent of bits in a classical CPU – become superconductors that allow electrons to flow freely, scaling up the curious behavior of quantum mechanics to enable the computer to work. Microwave pulses are used to vibrate the qubits, and when two neighboring qubits reach the same frequency, they become entangled. This means that measuring the state of one tells you

about the state of the other. Einstein famously poked fun at this idea, dismissing it as "spooky action at a distance," but since his death, it has been proved to be a real phenomenon.

Quantum supremacy

There's another reason for keeping your computer cold – it blocks out the effects of the outside world. Noise is the great enemy of quantum computing, and noise-free, error-corrected qubits are its holy grail. That's not to say noisy qubits aren't useful for some things, Google was able to claim quantum supremacy (where a quantum computer solves a problem no classical computer could solve in a feasible amount of time) with its Sycamore chip in October 2019, even though its 54 qubits (it was meant to be 55, but one broke) aren't fully error-corrected.

Google claimed that its computer could perform a random sampling calculation, where it verifies that a list of numbers has been randomly generated, in three minutes and 20 seconds. This task would have taken IBM's Summit, the most powerful classical supercomputer, over 10,000 years.

However, IBM disagreed and showed that, by changing the programming, Summit could have done it in 2.5 days.

It was also pointed out that this was a contrived problem, with little real-world application, written to take advantage of the quantum processor's strengths. A 54-qubit quantum computer can't claim to be a universal one, like our PCs are – this could require anything up to a million qubits – so Google's claims are of a quantum advantage in particular calculations, rather than full supremacy.

Google, naturally, disagreed with this, arguing that as Sycamore was still faster, supremacy had been reached. "Sputnik didn't do much either," Hartmut Neven, manager of Google's Quantum Artificial Intelligence Lab, said during a press event. "It circled the Earth. Yet it was the start of the space age."

A group from The University of Science and Technology of China has also claimed supremacy, using a photonic quantum computer – one based on the properties of light, using photons and beam splitters to achieve quantum superpositions – to perform a Gaussian boson sampling on 76 photons in 200 seconds. This is a problem so complex it has been estimated a classical supercomputer would take half a billion years to do the same thing. The Chinese paper, *Quantum computational advantage using photons*, was published in the journal *Science* in December 2020. Again, this is not a calculation that's been begging to be solved to help with a real-world problem, but one that plays to the strengths of the quantum processor.

Practical uses & quantum brilliance

So what can you do with a quantum computer right now? You could learn Qiskit, IBM's Python-based open-source SDK for working with quantum computers. Any algorithms you design in Qiskit can be run on either a quantum simulator or a real quantum computer accessible through the cloud, the idea is that people learn the basics of quantum computing models now, while the machines are in their prototype phases, before turning their knowledge loose on

full-sized machines when they are available.

One machine that's about to come online is at the Pawsey Supercomputing Centre in Kensington, near Perth in Western Australia. Quantum Brilliance, a venture capital-backed offshoot from the Australian National University, has created a room-temperature quantum computer made from artificial diamonds and, compared with the supercooled giants being touted by the likes of Google and IBM, they're impressively small.

"Today, it is a 19-inch rack," says Dr Marcus Doherty, one of the co-founders of Quantum Brilliance, about the company's current two-qubit system. "Over the next five years, we'll be shrinking that into something the size of a GPU card, scaling up to about 50 qubits." That is impressively small, beating the previous record-holder, a trapped-ion computer using lots of lasers designed in Innsbruck, Austria, that squeezed 24 qubits into two server racks. There's that timescale again – not now, coming soon – though Quantum Brilliance would have had something in the wild by now (it was scheduled for installation in June) if it weren't for COVID-19. Once it's up and running, however, what will it do?

"It's a functional quantum computer, but its purpose isn't necessarily to solve the world's problems, rather its purpose is to allow people to integrate and learn how to integrate quantum computers into their classical computer systems, and learn how to really make it work. This will then inform future generations about quantum computers," says Doherty.

Quantum add-in cards

The term 'GPU' comes up a lot in our conversation with Doherty; does he see a future 'QPU' becoming as common? "Different computing hardware is suited to different types of computational problems," he says. "Quantum computers offer advantages in certain problems that GPUs find difficult, so the future of computing is going to be a heterogeneous one, with different types

of accelerators that cluster together to do different jobs. It's about using the best hardware to optimise particular applications."

In Doherty's case, that hardware is made from synthetic diamonds. Where others use extreme cold or a combination of lasers and magnetic fields to cut their qubits off from the rest of the universe, the rigid structure of diamond's carbon lattice does the job here. "We all know diamond is an extremely hard material," says Doherty, "and one outcome of being a very hard material is that, even at room temperature, there is not enough thermal energy to create significant vibrations in the diamond. And vibrations are the principal means by which qubits can decohere. And so because there is that much lower vibration, there's much lower decoherence, which means that we can observe and manipulate and operate our qubits at room temperature. Our style of processing is much more analogous to classical computing, in that you have qubits, you encode information on them, manipulate that information, and read it out."

There's slightly more than non-vibrating carbon atoms going on in those diamonds, however. "Our qubits are associated with nitrogen atoms, which live inside a thing called the nitrogen-vacancy center." Imagine a perfect diamond, with an all-carbon lattice, then replace one of the carbon atoms with a nitrogen atom. Simple, huh? This NV-center has a useful property: it's photoluminescent (it emits light when stimulated) and this allows physicists to read the spin-state of the atom. So, how do you do that? "Via the light," says Doherty. "The NV thing has a remarkable property: the amount of light that it emits depends on the spin state. It is brighter when it's in one state, and darker when in another state. This is just one of those wonders of nature."

Doherty's approach to quantum computing means taking these non-vibrating bits of diamond and then vibrating them a tiny bit: "We have to

"Over the next five years, we'll be shrinking our current system into something the size of a GPU card and scaling up to about 50 qubits."

DR MARCUS DOHERTY





IBM engineers installing the System One quantum Computer at Germany's Fraunhofer Institute.

create an ultra-precise array of these NV centers in the diamond, so we have advanced fabrication techniques for creating the ingredients. Once they're in this array, we can manipulate them using microwaves and radio waves so they become entangled. And then we can manipulate that entanglement, to then process information."

All about timing

Another example of the timing problem quantum computing is suffering from comes from IBM's attempts to use a quantum computer to design new materials for batteries. Our current lithium cells are all well and good, but lithium mining, along with the extraction of the cadmium and nickel that also go into rechargeable batteries, takes a heavy toll on the environment and those who do the extraction.

IBM Quantum's Dr Gavin Jones, who has led much of IBM's research into battery chemistry, understated the matter somewhat, saying: "Quantum chemistry is complicated," in a webinar on IBM's YouTube channel. "There are many types of simulations we can perform," he says, "but quantum chemistry as practiced today on classical supercomputers struggles with many problems. This has mostly to do with the accuracy of the methods, and

how easily we can carry out these simulations. For example, one of the most widely used methods is a density-functional theory, but we have to carefully evaluate the accuracy of the methods by benchmarking, and this is time-consuming."

There's another problem with this kind of simulation: some don't reliably simulate particles with exotic or electronic properties, such as the radicals, biradicals, and unpaired electrons you find in batteries. "We like to use more accurate methods such as wave function methods to study the electronic structure of these types of systems," Jones continues, "but they can be very expensive in terms of the memory required and the amount of time required for the computation. We believe that quantum computers could help us perform the calculations more efficiently."

The general idea is that if you can simulate the interactions between all the electrons on the outside of atoms, how they bond with others when they react, then you can potentially create a new material that will have better properties than lithium, cobalt, or nickel when making the laptop batteries of the future.

Current quantum computers, at least the ones produced by IBM, aren't quite

up to the job. "We have had some degree of success, but there's still work to do," says Jones in the webcast. "We've developed several error mitigation techniques such as noise extrapolations and also strategies to reduce the number of qubits required to simulate larger molecules, exploiting symmetry and frozen cores, active spaces for reactions," he adds.

They are also using hybrid simulations, run partly on classical computing hardware and partly on real quantum hardware, but the challenges include the development of better quantum algorithms as well as improvements to the hardware itself. "The main challenges are that we need to develop and use better quantum algorithms," says Jones. "Because we have a limited number of qubits, we're reliant on algorithms in which you run a quantum circuit hundreds, if not thousands, of times in order to perform statistics."

"At present, we can only perform calculations of small chemical systems, or study systems in which we limit the number of orbitals being used, to map onto fewer qubits," he adds. "In general, the development of better quantum hardware and error mitigation techniques, or fully fault-tolerant qubits, would help."

Noisy quantum

Elsewhere at IBM, those things are under construction, partly as quantum simulators, that use classical computers to simulate the effects of quantum mechanics, and partly on real quantum computers. Quantum chemistry, the sort of simulations you need to do if you want to discover the properties of new materials for batteries or new drugs to treat diseases, means simulating the atoms in a molecule. "These are methods to solve the electronic structure," says Dr Ivano Tavernelli, global leader for advanced algorithms for quantum simulations at IBM's Zurich Research Laboratory. "So we present a molecule of water as one oxygen and two hydrogen atoms, then we want to

QUANTUM 101

We have a man called Max Planck to blame for all this. His discovery of energy quanta – the idea that the heat or light coming off something is not a constant force, but a stream of little lumps – won him the Nobel Prize in 1918.

This threw open the whole discipline of quantum mechanics, in which you'll find names such as Bohr, Fermi, Schrodinger, Pauli, Heisenberg, and Einstein.

Indeed, Einstein won his Nobel Prize for the discovery of the photoelectric effect in 1921, rather

than his more famous theories of relativity.

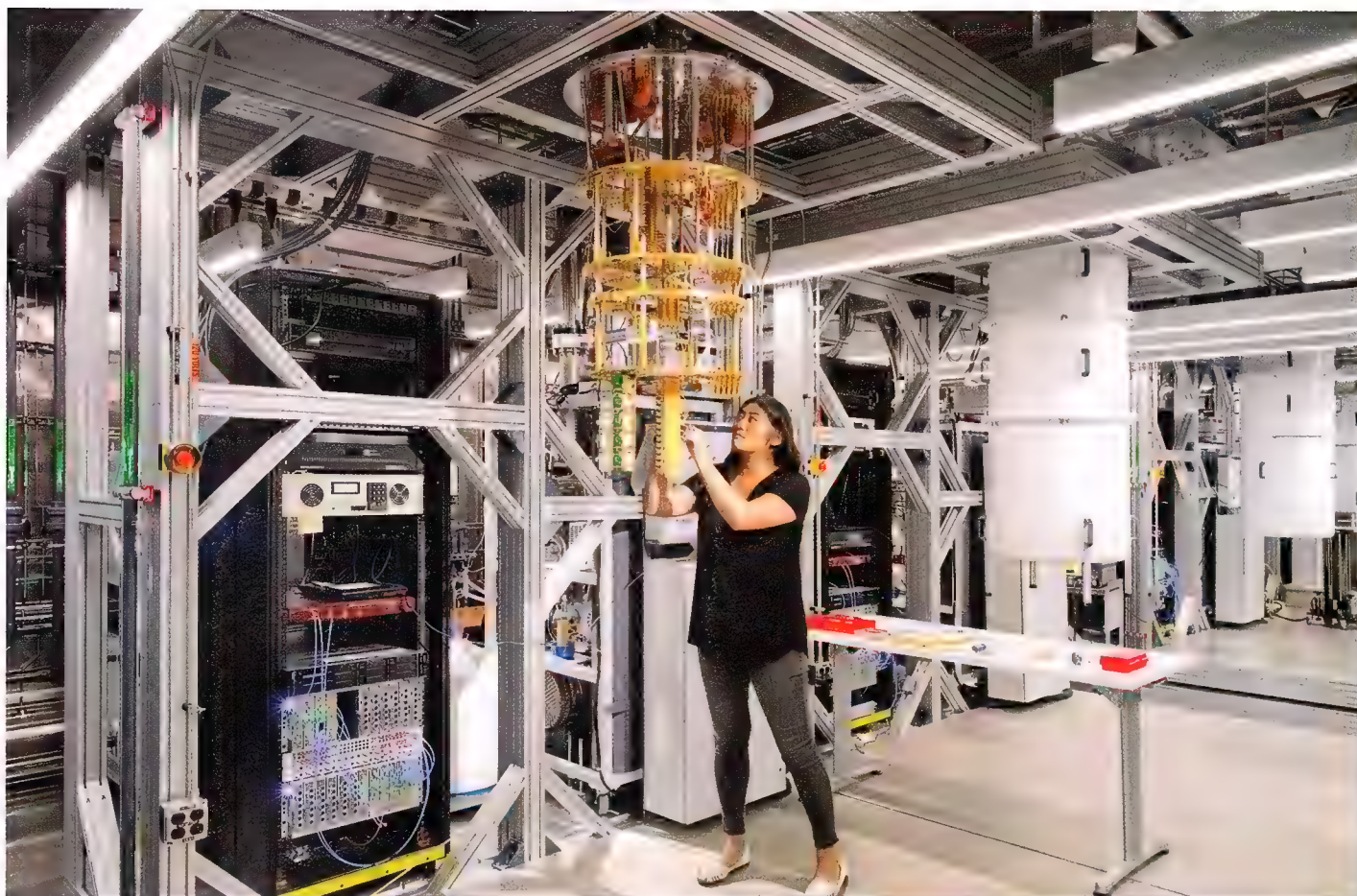
In the quantum world, particles behave both like points and little waves at the same time, with the magnitude of waves in any given region of space representing the probability of finding a particle at that location. Quantum computing relies on these strange properties of subatomic particles to do calculations in ways no classical computer could, using qubits instead of bits.

These qubits can be set at 1, 0, or both at the same time – known as a superposition – and often

have to be cooled to temperatures close to absolute zero in order to work to minimise the effect of noise, or outside interference, on the calculation.

The whole field is in its infancy but performs best on algorithms specially designed for it.

Quantum supremacy, where a quantum computer demonstrates abilities that no classical computer can match, has been claimed, but not yet fully proven, and we're a long way from general-purpose quantum computers that can replace your PC.



IBM Quantum scientist Dr. Maika Takita in the Thomas J Watson Research Center IBM Quantum Lab.

know about the energy of the system or the forces acting on the nuclei. To do that, you need to solve the Schrodinger equation [see boxout] and this can be done with classical computers but the cost rises exponentially with an increased number of electrons.

“What we are doing is to map this problem into a quantum computer, to solve a problem that is by nature quantum using a language that is also quantum by its nature. What we are doing at the moment is trying to optimise our algorithms to be able to execute the calculations on what we call near-term quantum computers – ones that have not yet been error corrected – so aren’t fully fault-tolerant. Our goal is to show the potential for a quantum advantage using these kinds of machines before we get fault-tolerant machines.”

A noisy quantum computer is still a useful one, it seems, but attempts to reduce the noise are ongoing. “There are

two strategies,” says Tavernelli. “One is to continue to improve the hardware and reduce the amount of noise in the qubits’ operations as well as in the measurement of outcomes. The other is to apply error mitigation schemes, so we can make algorithmic corrections to the calculations we perform with noisy devices.”

Tavernelli also has shocking news for those using two or 50-qubit machines: they will soon become obsolete. “At the moment, you will need roughly 1,000 physical qubits, noisy qubits, in order to make a single error-corrected, logical qubit,” he says. IBM’s roadmap is to learn what it can now, then try to set up such a device in the near future. “This will be reached in 2027, more or less. We will get to thousands of qubits, then the transition from noisy to fault-tolerant machines can begin,” he says.

This sounds like a major threshold to cross, what will happen then? “If everything goes smoothly, our theory

shows that these machines can correct all errors that will happen, so there are no limits. Even when quantum advantage is demonstrated, for many applications, it doesn’t mean a quantum computer will completely substitute for a classical one, so you’ll never get a [quantum] laptop, not during my lifetime. But there will be many applications where the quantum computer will significantly improve the predictions of graph discovery, fundamental physics, optimisation, and machine learning. So you will be able to do things that are impossible even to think of nowadays because of the exponential scale.”

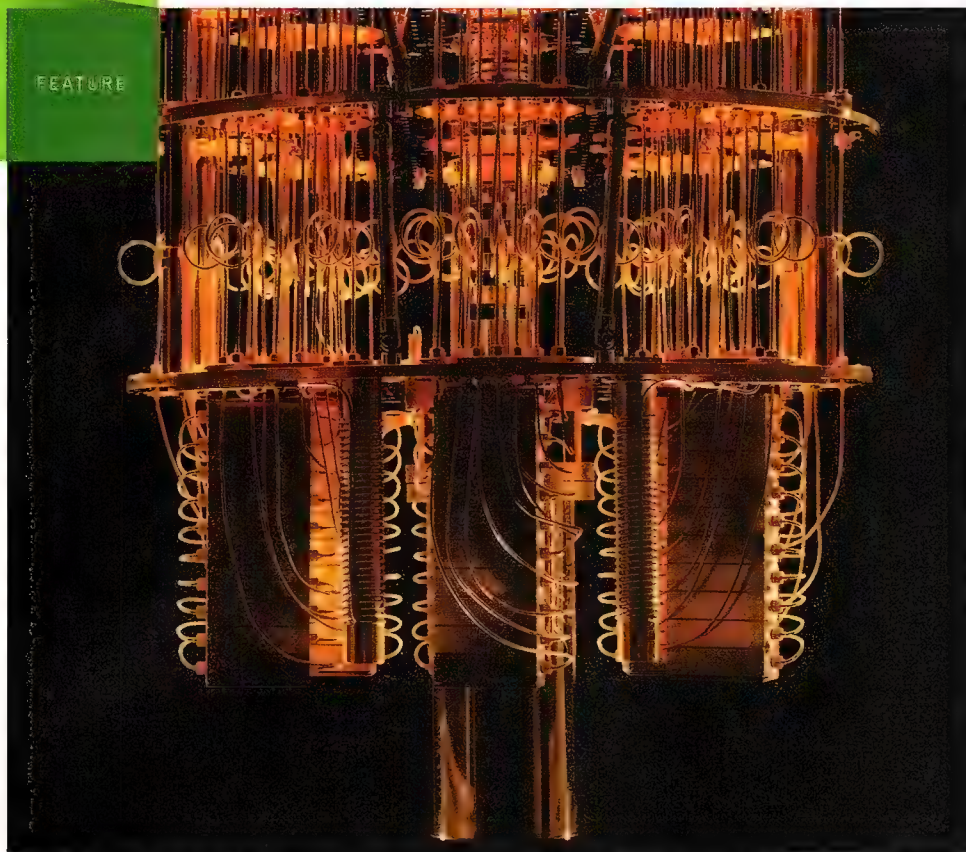
Lightspeed particle smashing

That scale means quantum computing could be used to process enormous data sets, such as that produced by the Large Hadron Collider. This particle accelerator, which exists as a giant ring 27 kilometres in circumference beneath

“At the moment, you will need roughly 1,000 physical qubits, noisy qubits, in order to make a single error-corrected, logical qubit.”

DR IVANO TAVERNELLI





IBM's quantum dilution refrigerator, used to keep its quantum chips at a temperature colder than outer space.

the French-Swiss border, produces about 90 petabytes of data per year, and less than one percent of it ever gets looked at.

Tavernelli's colleague Dr Panagiotis Barkoutsos, also at IBM Zurich, is attempting to bring current quantum computers to bear on the problem. "The goal that's been set is that we want to find physics that can compete with or go beyond the standard model [the theory that describes three of the four known fundamental forces that make up the universe] and this is done by experiments in the Large Hadron Collider. The amount of data produced from an experiment is enormous, and the natural question is, can quantum computers help to process all this data more efficiently?"

"We're not using words like advantage or supremacy because, in data, the quantum advantage is to have a meaningful simulation that's performed faster and better," says Barkoutsos. He and his colleagues have been testing it on old data associated with the

production of the Higgs boson, one of CERN's greatest discoveries. This particle is associated with a fundamental field that gives other particles their mass. The more a particle interacts with the Higgs field, the heavier it is. The particle is a visible manifestation of the field, like a wave on the surface of the sea.

Through their work, IBM's researchers have shown that "quantum machine learning, in the context of vectors, can perform as well as its classical counterparts can perform," says Barkoutsos. "We're doing experiments out to 15 qubits, and we'll also use a 27-qubit device. The algorithms that we're currently developing are meant to be used on near-term computers, so if we had a fault-tolerant quantum computer, we would have to think in a different way. When fault-tolerant quantum computers exist, we'll be able to rethink the algorithms, and rethink the way that we are doing things to go beyond what we have already done."

Is it pointless?

Everyone we spoke to for this feature seems certain that the study of quantum computing will continue, and will eventually succeed. Others, however, have voiced concerns that the noise problem may never be overcome, a fully fault-tolerant quantum computer may never be built, and the computers that exist today aren't really all they're cracked up to be. In the words of Isaac Chuang of the Massachusetts Institute of Technology, "Quantum computing today is actually, from a practical standpoint, quite useless, other than for generating publicity."

A *New Scientist* article from August this year contained not only the above quotation from Chuang but also contributions from two other professors. Gil Kalai, a mathematician at Israel's Hebrew University of Jerusalem, said: "My analysis asserts that quality error correction won't be possible."

Meanwhile, Sabrina Maniscalco at the University of Helsinki in Finland is of the opinion that: "Finding a remedy to the effect of noise induced by the environment is not just... a technological issue, but more of a conceptual and foundational one. I would say that I am hopeful, rather than confident."

"What if I told you that there is no law of physics that tells us that we cannot go beyond this noise problem?" says IBM's Tavernelli. "There's nothing proven that tells us that we will not be able to go to fault tolerance. It is a difficult mission, that much is clear. So we may need to go slow, we may need to do things in a manner that is difficult to do in an experiment, but still, no law tells us we are not going to be able to go beyond the noise problem."

Tavernelli certainly sounds more positive than some of his counterparts. "Although there is no law, I don't believe we will ever be able to have one single physical qubit standing without noise," he says, "For this reason, there are correction schemes that tell you we are going to have physical qubits that can be mapped into a logical qubit, and we're



"Quantum machine learning, in the context of vectors, can perform as well as its classical counterparts can."

DR PANAGIOTIS BARKOUTSOS

going to have more advanced error correction schemes that tell us we're going to connect different physical qubits one with the other, to create a logical qubit that's self-correcting through the error correction schemes," he explains. "There may be an overhead in the number of qubits that are required for the generation of a single logical qubit, but still, you're going to get one unit of information that's going to be self-correcting," Tavernelli concludes.

Doherty foresees other problems. "The great advantage of quantum computing is that for a fewer number of resources, you can manipulate larger amounts of information more efficiently," he says. "That's because you can encode more information onto fewer resources. That ability to encode more, and to manipulate more, stems from two physical properties. The first is quantum superposition, which people often describe as being in two places at once, and the other is entanglement, which is Einstein's famous paradox, where you can have two things correlated with one another that are not necessarily near each other. You must be able to entangle qubits in order to get the full advantages of quantum computing," Doherty adds.

"Then there's a big but: you can't get all the information out at once. You can only ever get out a certain amount, and that's the devil of quantum mechanics. What it means is that, unlike a classical computer, where you can read the information in its entirety, in a quantum computer, you can only sample the information and get some of it out. So this means that quantum computers are probabilistic and statistical. The art of making quantum algorithms – which isn't easy, and we, the big 'we', don't know how to do that well at the moment – is to create something where you can manipulate the information efficiently, but also collapse it in a way that you can get it out efficiently, which is often the hardest thing."

Commercial application

And while Tavernelli doesn't think you'll see a quantum laptop, IBM is spreading its quantum computers across the world, with the installation of the IBM Quantum System One at Germany's Fraunhofer Institute, a research organisation focused on applied science, i.e. actually making stuff. The System One contains a 27-qubit Falcon superconducting processor and will be used to "solve major business and societal problems," according to the institute's press release.

Quantum computers right now are much like the System One, following the supercomputing model of accessing

them via classical computers, networking them to allow multiple points of entry, and using that expensive processing time efficiently.

Doherty imagines quantum data centers and even quantum robots. "In principle, our quantum computers can be everywhere," he says. "We believe there's a variety of important applications in robotics, autonomous systems, and space systems. We're increasingly seeing autonomous, robotic, systems encroach on our everyday lives for work and entertainment, and they rely more and more on things like AI and machine learning. So we may see quantum computers in our homes to support those sorts of computing requirements."

Just what is it about AI workloads that makes them so suitable for quantum processing? It seems a world away from simulating electrons. Doherty explains: "Depending on how you construct your workflow with AI, there are sometimes cases where you may be processing an image or a video, or you might be listening to a person's voice, and you've got to predict what will happen and in what order. Machine learning is very exact at extracting and guessing what is happening in each moment in time, but classical computers find it very difficult to go 'what's the most likely sequence of events?' But a quantum computer is quite adept at doing things like determining the most likely sequence of things actually happening."

There are plenty of new developments and breakthroughs in quantum computing. In August 2021, Japan's Riken Center for Emergent Matter Science announced that it had demonstrated a triple-qubit silicon-based system that shows entanglement is possible across three qubits, making things like error correction and scaling up the number of qubits easier. Earlier, researchers at another Australian outfit, the UNSW School of Electrical Engineering and Telecommunications, demonstrated control of quantum spin qubits by using a crystal prism – something that could potentially be scaled up to control millions of qubits at once.

Research by *The Quantum Insider* predicts that the market for Quantum computing as a service will hit US\$5.5 billion by 2025 and US\$35 billion by 2030 and, despite the note of caution sounded by some academics that the discipline is a bit of a dead-end, we're going to see a lot more of this technology – whether accessed through the cloud, sitting in a data center, or even a GPU-sized card controlling your house robot or self-driving car. It looks as though Quantum computing is here to stay.



SCHRODINGER'S EQUATION IS DEAD AND ALIVE

Perhaps better known in popular culture for his cat, Erwin Schrodinger (pictured) was a Nobel Prize-winning physicist who was in at the beginning of quantum theory. His equation acts as quantum mechanics' equivalent of Newton's second law – the one that goes $\text{force} = \text{mass} \times \text{acceleration}$.

Newton's law predicts how a physical system will move over time, and so Schrodinger's equation does the same for an isolated quantum system. Given a known set of initial conditions, it can predict the evolution of the wave function of a system, making it useful in quantum chemistry.

Schrodinger's Cat is a thought experiment, please don't try to carry it out, you'll only end up with an unhappy cat and possibly some unwanted attention from the FBI. He came up with the idea during a discussion with Einstein, in an attempt to point out what he saw as problems with quantum mechanics.

It goes like this. You have a box from which no radiation can escape. In the box, you place a cat (although any small mammal would do), a vial of poison gas, and a lump of unspecified nuclear material. The chance that the nuclear material will release a particle that will penetrate the vial, release the gas, and kill the cat is about 50/50. Once you seal up the box, you have no way of knowing (it's a very docile cat, apparently) what has happened until you open it and observe the state of the system. Therefore, while the box is closed, the cat can be said to be in a superposition – both alive and dead at the same time.

This was intended to poke fun at the Copenhagen interpretation of quantum physics, the prevailing view at the time – if the cat survives, it remembers nothing of being dead, so at which point did this superposition happen? These days, it's arguably more famous than its author, thanks to its inclusion in novels, poetry, TV, games, and movies. ■

ULTRA-MOBILE COMPUTERS & YOU

From subnotebooks to Ultra Mobile PCs, these machines have come and gone over the years. John Knight asks if we are about to see their return.

Whatever you want to call these things, in this feature we'll be exploring the history of the ultimate in tiny computers – not including the now-ubiquitous smartphone. We'll start with early and ground-breaking models in the 1980s, through to the more mature models in the '90s. We'll also take a look at the UMPC craze of the 2000s and the wilderness years that followed, and dive deep into the resurrection of this form currently taking place in China, examining the models that are on the market today and where they're going in the future.

So how do you classify these computers? Well, to pull some rules out of nowhere, we're going to define these as something that can fit ideally in your pocket; has some kind of integrated keyboard; and something that has a screen that comes in under 9-inches, at a stretch, though less than eight would be ideal.

For simplicity's sake, we also need to establish what to call these things too. We've decided to settle on "pocket computers" for smaller machines, and "ultra-portable" for the bigger offerings, though it's worth pointing out these are pretty interchangeable terms, too.

Of the many super-small computers out there, we've had to whittle down the choices to just a select few – sadly, there are only so many small machines we can cover, but hopefully it's enough to give you a flavour of the ultra-portable history.



THE BEGINNING OF POCKET COMPUTERS

Defining the first pocket computer is difficult due to the popularity of electronic organisers in the 1980s. Nevertheless, the title of first real pocket computer is generally awarded to Radioshack's TRS-80 Pocket Computer (aka. Tandy Pocket Computer), so let's start there.

Infancy

The TRS-80 Pocket Computer was launched in July 1980. Despite the American branding, this machine is actually a re-badged Sharp PC-1211 from Japan.

This 70g handheld may look like a normal scientific calculator, but it also packed a QWERTY keyboard, 1.5KB of RAM, and two 4-bit CPUs running at 256KHz. Most importantly, it included Sharp BASIC, making it the first genuine pocket computer.

But this is a far cry from a x86 "IBM-Compatible" PC. For that title we need to turn our attention to the DIP

Pocket PC – better known as the Atari Portfolio. Released in June 1989, the DIP Pocket PC was the first PC-compatible pocket computer, manufactured by DIP Research, UK. DIP's machine caught the eye of American computing giants Atari, who re-badged the machine as the Atari Portfolio, or Atari PC Folio in continental Europe.

Sporting a 4.9MHz 80C88 processor, the Portfolio had 128KB of RAM, half of which was used for system memory, the other half for user storage. Housed in the Portfolio's 256KB ROM chip was DIP DOS 2.11: an MS-DOS compatible DOS clone from DIP Research. The unit measured only 7.5 x 4 x 1.25in, and the lack of an LCD backlight, hard disk, or internal floppy drive allowed for excellent power efficiency, requiring only three AA batteries to operate.

But 128KB split two ways is a tiny amount of memory and storage, so Atari sold RAM extenders, plus other add-ons

such as serial data transfer modules, and software ROM cards. The weird 240x64 pixel display means there aren't many games for this machine. None of these drawbacks matter, because the Atari Portfolio is a film star, ever since its famous cameo in *Terminator 2*.

In October 1989, the Poqet PC was launched by the Poqet Computer Corporation. Of all the machines here, the Poqet PC is probably the most technically impressive for its time, but at \$2,000 (around \$4,000 in today's money) it should have been.

The Poqet's stylish red-on-charcoal case is a bit wide at 8.8 x 4.3 x 1in, but it uses that space perfectly with an excellent keyboard. Powering the machine was an Intel 80C88 processor @ 7MHz, with between 512 and 640KB of RAM. CGA-compatible graphics were run through a non-backlit monochrome display. MS-DOS 3.3 was built into ROM, with an internal 22KB RAM drive.

The Poqet was designed around PCMCIA expansion, helping establish the standard by being one of the first machines to use it. Two slots were provided, one on each side, and special Poqet software was released on ROM cards.

The Poqet runs on just two AA batteries, which is all it needed due to pioneering energy-saving techniques. Battery life is between 50 and 100 hours, which would last most users weeks or even months.

Confident youth

In 1991, Hewlett Packard released the HP 95LX Palmtop. While not as technically impressive as the Poqet PC,



HOW CAN I STILL USE THESE THINGS?

For anyone still using these computers, the main task is usually writing. They provide simple text editing, without the clutter and noise of a modern OS. Some use their old-fashioned Lotus spreadsheets, or as Linux dumb terminals.

Some of the more powerful devices here can be a way to play DOS games, or use OS/2 or Windows 3.x (or Windows 9.x with later machines) on real hardware. Of course, copying files between these machines and modern computers can be a challenge.

If your old computer has a PCMCIA slot, you're in luck: there are plenty of cheap adapters online for using Compact Flash or SD cards as a replacement hard drive.

Simply remove the card when you're not using it, then plug it into a modern PC.



Hewlett Packard's HP 95LX got the design just right, with excellent battery life, plenty of features, and a low price.

at \$700 it was far cheaper.

This well-packaged pocket computer brought mobile computing to the masses. Touted as a "PC XT in your pocket", the 95LX came with both MS-DOS 3.22 and office suite Lotus 1-2-3 built into ROM.

Rather than an Intel 8088 processor, the 95LX used an NEC V20 clone @ 5.37MHz and came with either 512KB or 1MB of RAM. The 95LX was truly portable, weighing just 312g and measuring 6.5 x 3.5 x 1in. Two AA batteries provided around 30 hours of running time. The 95LX used SRAM storage, with a maximum card size of 32MB.

Despite the impressive packaging, it was an add-on that truly immortalised the 95LX. The Motorola NewsStream slide-on attachment would connect to a wireless online database, allowing access to email, spreadsheets, and news services – all without a phone or modem.

A weakness was the 95LX's display, which was non-backlight, monochrome, and only allowed for a 240x128 "quarter CGA" resolution. This meant many graphical programs simply couldn't display on its hardware. These problems were later addressed with the HP 100LX (1993) and 200LX (1994) which came with more RAM – 1 or 2MB respectively – and a 640x200 display. Coupled with MS-DOS 5.0, these machines could even run Windows 3.x.

Maturity

In the 1990s, the Rolls-Royce of ultra-portables was the Toshiba Libretto range, designed to fit a full Windows PC

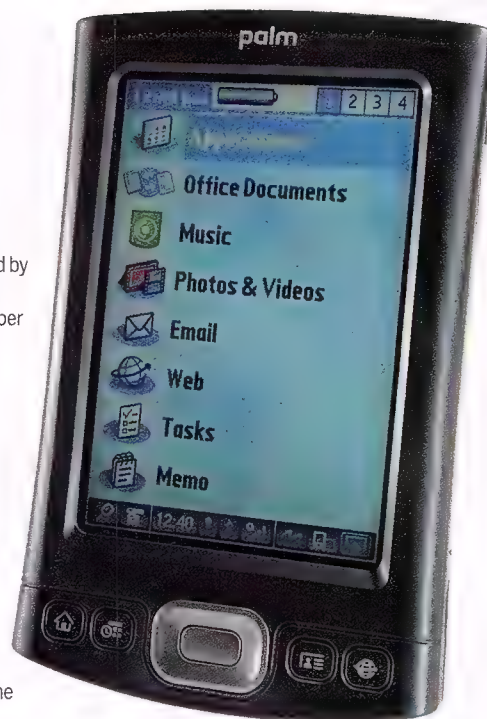
PALM OS PDAS

If you said "palmtop" in the '90s, these are the machines that came to mind: Portable Digital Assistants (PDAs), most of which were powered by Palm OS.

These devices sat somewhere between proper computers and simple electronic organisers. Instead of a small keyboard, these Palm OS devices mainly used stylus input, with users required to learn the Graffiti handwriting recognition system. Data was transferred between your PDA and PC with a sync-cable or infra-red adapters.

While Palm OS devices usually came with only a collection of basic office utilities, several megabytes of storage allowed users to add downloaded games to their devices. These games ranged from simple *Minesweeper* clones to something more advanced such as *Sim City*, all the way up to *Doom II*, as seen on the Tapwave Zodiac gaming handheld (2003).

Palm started the millennium with a bright future and a strong market, but its devices (and PDAs in general) became more redundant with each advance in smartphone technology. HP bought out Palm in 2010 after the company developed its new webOS but then threw in the towel after poor sales.



into the dimensions of a paperback novel. Toshiba products have always been beautifully made, and the Libretto range was no exception. Launched in April 1996, the Libretto 20 measured 8.2 x 4.5 x 1.3in, powered by an AMD 486 DX4 CPU @ 75MHz, with 8MB of RAM (upgradeable to 20MB), a 270MB hard drive, and a 6.1in TFT display. Floppy and CD-ROM drive access were available through PCMCIA expansion. Battery life was two hours.

The Libretto has a quirky mouse input method: an IBM-style "nub" is located on the right screen bezel, while the mouse buttons are on the top side of the lid – your thumb controls the pointer, your fingers click the buttons. These machines weren't cheap, however, with

prices starting around \$2,000, and the first models originally only sold in Japan.

The Libretto packs quite a punch but isn't perfect. Most owners complain about its slow and noisy mechanical hard disk, and while it has a keyboard, it isn't for the fat-fingered. Nevertheless, Librettos are quickly establishing themselves as great portable gaming PCs with retro enthusiasts, and those nasty hard disks can be changed for a compact flash card with a simple adapter.

The original ultra-portable Libretto range continued to be upgraded until it was discontinued in Europe and the US in 1999, and in Japan in 2001.



Despite the Atari Portfolio's technical abilities, it will always be associated with John Connor hacking an ATM in *Terminator 2*.



The Poqet PC's design meant users rarely sat through boot sequences, and office tools were available via a simple hotkey.



Toshiba's Libretto series was initially made for Japan only, but was later sold internationally after wowing consumers.

BEYOND 2000 THE WILDERNESS YEARS AND THE UMPC WAVE

Miniature laptops started dying out after the new millennium. Windows CE was becoming the de facto standard for portable computers, providing all the quirks of a PC without the benefits of a x86 eco-system. In the early 2000s, Microsoft made a failed attempt at introducing a tablet PC standard, including its much-maligned Windows XP Tablet PC Edition. Undeterred, Microsoft would see success in the mid-2000s with a new design standard.

The UMPC standard

In 2006, Microsoft released the UMPC standard, or "Ultra-Mobile PC". This specified a screen of eight inches or less, with a minimum resolution of 800x400. Screens were to be touch-sensitive, and many UMPCs used stylus input. In preparation for the new machines, Microsoft made minor tweaks to Windows XP to make it more usable with small screens and touch inputs.

One of the first UMPCs released was the Samsung Q1. Launched mid-2006, the Q1 featured a 7-inch touchscreen with a small-key thumb keyboard split

in two, with each half on either side of the screen.

Inside the quirky new tablet was a 900MHz Intel Celeron and 512MB of RAM, plus Wi-Fi, Bluetooth, an ethernet plug, and two USB ports. All respectable for the time, other than the 4200RPM mechanical hard drive. However, of the many UMPC variants, the two most important machines were probably the Sony Vaio UX series, and the OQO Model 02.

David and Goliath

Sony had a head start in 2004 with its U series of PDAs, but these lacked an integrated keyboard. For the new UMPC standard, Sony's Vaio UX Micro PC came with a small keyboard tucked behind a sliding screen. Primary buttons and controls were on either side of the 4.3-inch screen, with a rubber nub for mouse control that was used with the right thumb.

Ground-breaking for its time, it included a front-facing camera, fingerprint reader, Wi-Fi, and SIM slot. Powering the Sony was a choice of Intel Core or Core 2 Solo processors, with 512MB or 1GB of

RAM, and between 16-100GB of storage.

Competing against the Japanese giant was American manufacturer OQO. Despite its niche position, OQO received a huge market boost when Bill Gates introduced its Model 02 at 2007's Consumer Electronics Show.

Previous OQO models were already close to Microsoft's standard, but the Model 02 brought OQO up to spec with stylus input and Wi-Fi. The Model 02 also had a slide-out keyboard hidden behind its screen, as well as a nub-controller and mouse buttons.

Powering the OQO was a 1.6 GHz VIA C7-M ULV processor, 1 GB of RAM, and 64 or 120 GB of storage. The Model 02 also had a SIM slot, and although it didn't include a camera or fingerprint reader, it had a bigger display, a better battery, and HDMI output.

Both brands had a choice of mechanical or solid-state hard drives. The mechanical hard drives were diabolical. The tiny keyboards didn't win many fans either, but the OQO had a nice amount of key travel, whereas the Sony keyboard lacks any feedback. The Sony is let down by its 2-3 hour battery life, while the OQO is let down by its underwhelming VIA processor.

Despite these flaws, both models were hugely popular. The OQO Model 02 won a raft of industry awards, while the Sony Vaio UX series became a film star, featuring in such movies as *Terminator Salvation*, *National Treasure*, *Casino Royale*, and

USING THESE THINGS PT 2

While it may be handy to keep a running version of Windows XP for old proprietary software, these machines could be ideal candidates for lightweight modern operating systems, such as "lite" Linux distributions, BSD variants, AROS, or Haiku.

For those willing to dig inside their machines, a modern SSD or IDE to SD-card adapter could provide an upgrade for anything lumbered with a mechanical hard drive. Other than increased reliability, these modern replacements should provide improvements to both performance and battery life.



The mechanical hard drive was the Sony Vaio UX's Achilles' heel, but a retrofitted SSD makes a great restoration project.



Samsung's Q1 UMPC helped pioneer this two part thumb-keyboard design. Thankfully, it wasn't a design that lasted!



OQO's Model 02 was a beautiful piece of engineering. In a just world OQO would still exist, but it ceased operations in 2009.

An Asus Eee PC 701, with fountain pen for scale, running Ubuntu Netbook Edition.



THE NETBOOK WAVE

Most netbooks are too big to be called ultra-portable but are usually the first thing people mention when asked about tiny computers. While numerous products could claim to be the first netbook, the Asus Eee PC in 2007 kickstarted the category. The Eee PC was nine inches wide, with a 7-inch display and a decent keyboard. Costs and power consumption were cut by removing optical drives, and early models shipped with a custom version of Xandros Linux and a 4GB SSD. Response to the Eee PC was overwhelming, spawning many rivals, but most netbooks from this point shipped with standard mechanical hard drives and Windows XP. Most grew in size to between 10 and 14-inches. Netbooks were most popular with students: they fit easily into a backpack and could be typed on well enough for assignments. Netbooks stole a sizeable market share from both laptops and pocket computers and were popular for several years. However, most had awful Intel Atom processors, which were incapable of running Vista or Windows 7. While netbooks are still available, their market share has been lost to Chromebooks and tablets.

Quantum of Solace – there was even a special 007 edition!

A dying breed

Unfortunately, the UMPC craze didn't last, as people turned to netbooks and smartphones. Nevertheless, there were some standout models in the UMPC's waning years. Starting with the Fujitsu LifeBook series, models such as the



The Pandora was a marvel of open-source philosophies and innovative design, but will we ever see its sequel?

U810 (2007-08) and UH900 (2010) formed part of the second generation of UMPCs with much-improved specifications. The U810 is a particular standout, with twice the battery life of first-generation UMPCs.

Our favourite machine from this time is probably the HTC Shift X9000 (2008). The Shift used a unique slide-and-tilt mechanism that brings its keyboard out from behind a 7-inch display, resulting in something that looks and functions like a clamshell laptop but folds away flat for storage, or that can be used as a tablet.

Under the hood is an 800-MHz Intel A110 processor, with Intel 945 graphics, and 1GB of RAM. This was just enough to run Vista at the time, but many people ditched Vista and "downgraded" to XP. This provided a much faster experience and a decent gaming platform for anything from the XP era and earlier.

Non-PC portables

As the 2010s advanced, UMPCs died out and netbooks weren't far behind. The iPad popularised tablets and

everyone had smartphones – those still using PCs reverted to traditional laptops and desktops.

In the non-x86 world, things were different. In 2012, the Raspberry Pi shook up hobbyist computing, spawning new cottage industries. Unlike the x86 world, which was dominated by Windows, these new machines ran ARM processors. And in ARM world, Linux was king.

The Pi's minuscule proportions could be crammed into tiny spaces, spawning countless designs, including new pocket-sized laptops, such as the LapPi, Nano Pi2 UMPC, Adafruit Mini Handheld Notebook, LEGO Raspberry PiBook, and the imaginatively titled "Raspberry Pi & Arduino Laptop".

Beyond the Raspberry Pi scene, 2016's PocketCHIP provided ultra-cheap thrills. Based on the \$9 CHIP computer, and retailing for \$69, the system uses a keyboard design similar to a Sinclair ZX81, matched with a 4.3in colour LCD. The system is hackable as it runs on a regular version of ARM Debian. A D-pad is included for gaming emulation, with 5-8 hours of battery life.

However, if we go back in time even before the Raspberry Pi, there was one brilliant machine: the Pandora. Released in May 2010 by OpenPandora, the Pandora is like a cross between an HP 95LX and a Nintendo DS. Somehow its tiny pocket-sized clamshell design managed to fit a QWERTY keyboard, dual analog sticks, face buttons, and even a D-pad, with a 4.3-inch monitor.

Two SD slots, a headphone jack, and multiple types of USB port allowed for easy expansion, while the battery gives 10 hours of realistic running time or 20 hours of economical use. Standby lasts a week.

Powering the machine is a 600 MHz Texas Instruments OMAP3530 CPU, with PowerVR SGX graphics, and 256 MB of RAM. Not exactly a computing powerhouse, but it didn't need to be. For the operating system, the Pandora provided two lightweight Linux distributions based on the Debian ARM repository.

Unfortunately, the production run was limited, so these unicorns are guarded jealously by their owners. If you ever see one for sale, snap it up.



THE SHENZHEN REVIVAL

Although traditional manufacturing giants have largely abandoned pocket computers, the format has seen a renaissance via boutique manufacturers from Shenzhen in China. These companies have avoided the pitfalls of traditional product development by crowdfunding and skipping normal retailers in favor of online stores such as AliExpress, Amazon, and eBay.

Of all the boutique makers, GamePad Digital, or GPD, is one that can truly be called a trendsetter. GPD has developed a cult following redesigning neglected forms into something truly desirable.

GPD

GPD first caught the world's attention in 2015 with the XD: an ARM-based Android gaming device, designed for easy emulation and styled like a Nintendo DS. It was an instant hit among retro gaming fans, due to its simple design, clever tweaks, and generous expansion.

Following the XD's success was the GPD Win: a Windows 10 handheld with console controls. After moderate success with the Win, GPD stepped away from gaming to make something very different: the Pocket.

The Pocket milestone

The GPD Pocket reinvented the discarded netbook format by shrinking the design to a mere seven inches overall. Despite its diminutive size, clever engineering compromises allowed for a keyboard that was reasonable for typing on, encased in a

sturdy aluminum chassis. Customers could choose between either Windows 10 or Ubuntu pre-installed.

The Pocket was a runaway success, and in 2018, GPD released the Pocket 2, which added a more powerful Intel Celeron CPU and swapped the “nub” mouse for an optical touch sensor. While GPD's earlier products were designed around gaming, the Pocket was a hit with writers and students, who wanted to work anywhere, any time, with a product that was truly compact and portable.

Its design hit a sweet spot that spawned numerous imitations from Shenzhen rivals, such as One-Netbook's One Mix Yoga series (2018), which has a 360-degree hinge and stylus support; and the Chuwi Minibook (2019), which also has a webcam, and a cheaper price.

Interest in the GPD Pocket led to other niche products, such as the MicroPC – a cheaper, ruggedised handheld for engineers with an RS-232 port; and the P2 Max, a tricked-out 8.9-inch netbook GPD has dubbed ‘the world's smallest ultrabook’.

GPD is still selling the Pocket 2, while One-Netbook's line has morphed into the OneMix series. You may still be able to find the older 7-inch OneMix2 for sale online, while the OneMix3 stretches to an 8.4-inch screen, and the OneMix4 is a full 10.1-inch netbook.

What about gaming?

For many years, companies have tried to make something ultra-portable and



capable of modern gaming. However, the mobile processors needed by such small machines have always been a generation behind desktop PCs. But now it seems we finally have the right technology.

In 2016, GPD launched the Win, with an intel-based Windows 10 touchscreen handheld. Although its QWERTY keyboard couldn't be used for proper typing, its design allowed dual analog stick controls, face and shoulder buttons, and a D-pad.

The Win was a reasonable success and was followed in 2018 by the Win 2, which upped the screen size from 5.5 to 6-inches, ditched the lousy Atom processor for an Intel Core m3, and doubled its RAM from 4 to 8GB.

While these machines were great for indie gaming and emulation, they were unrealistic for modern AAA gaming, and their keyboards were too small for proper typing. But in 2021, the Win 3 was launched, and it's a far more compelling games machine.

The design has changed, with GPD ditching the clamshell design for something resembling a Nintendo Switch, but slide the screen upwards and it reveals a keyboard, like an old Sony Vaio. The touchscreen is 5.5-inch, with an overall footprint of 7.8-inch.

The Win 3 is powered by the Intel Tiger Lake platform, sporting a 4.2 GHz Intel Core i5-1135G7 CPU and a Gen12 Iris Xe GPU. There is now 1TB of NVMe M.2 SSD storage and 16GB of RAM. All this allows for a viable gaming experience, even if it won't rival



The GPD Pocket combines UMPC and netbook design elements into something better than either format.



Valve's Steam Deck is too big for this category and has a virtual keyboard, so no good for writing articles on it.



Shenzhen is often referred to as "China's Silicon Valley"

WHY SHENZHEN?

Shenzhen is often dubbed "China's Silicon Valley", with a techno culture unlike anywhere in the world. What would normally take months of development in the West takes weeks in Shenzhen. Rather than supplying traditional brick-and-mortar stores, most companies sell online. Huge bazaars of electronic components allow developers instant access to the parts they require. Need an arcade button? Then simply go to the stall selling buttons. Need an analog stick? There's probably a stall for that too.

In Shenzhen, it's not uncommon to see people rummaging through bins, however, they're looking for old phones to salvage parts, rather than searching for food.

This hyper-availability of parts has created a market of niche gadgets where anything gets made. Ideas are copied (or stolen) and improved upon. Open-source software and hardware are popular, with Linux and Android powering most gadgets.

desktops. GPD even provides a customised image of Ubuntu MATE for Linux users. On the downside, its small, flat keyboard has not been well received, as it gives bad feedback and appears to have reliability issues.

There is competition in Shenzhen and, for those who prefer team AMD, there is the Aya Neo, which packs a 4GHz AMD Ryzen 5 4500U APU and a 7in touchscreen. For an Intel rival, there is the bulkier OneXPlayer Handheld PC, with a 4.8GHz Intel Core i7 1165G7 CPU, Intel Iris Xe 96 EU GPU, and an 8.4-inch touchscreen. However, neither the Neo nor the OneXPlayer has physical keyboards: you use an on-screen virtual keyboard, so neither fits our specs for an ultra-mobile PC.

The GPD Win 3 and OneXPlayer Handheld PC are available at online stores such as AliExpress and Amazon, while the Neo is available from Aya's website.

But I want a proper keyboard!

If none of these options take your fancy, there are gaming machines that retain a

clamshell design, but add game controller features. The first is One-Netbook's OneGx1 (2020). During normal operation, it looks like a small netbook, but has RGB lighting and a rear cooling design "borrowed" from Alienware gaming laptops and is transformed by two controller paddles that attach to either side.

Reviews are mixed. Some love it, others find it flawed and impractical. The 7-inch screen has stylus support, and the machine has an overall footprint of 8.4-inches without paddles. It is older than other models here, with a tenth-generation i5 core processor that maxes out at 4GHz.

The last machine to consider is the GPD Win Max. This essentially enlarges the older Win 2 design with a proper typing keyboard and places the touchpad, control sticks, and buttons above the keyboard.

While it started life in 2020 with the same family of Intel CPU as the OneGx1, the new 2021 model comes in two varieties: a quad-core 11th

Gen Intel i7-1195G7 CPU (5GHz maximum), or an eight-core 4.2GHz AMD Ryzen 7 4800U APU.

The Win Max has an 8in touchscreen, 16GB of RAM, and 1TB of M.2 SSD storage. Reviews have been positive, and both the Win Max and OneGx1 have excellent I/O expansion. Both are available on sites such as AliExpress and Amazon. ■

ONLINE PRICES*

GPD Pocket 2	\$625 - \$900
GPD MicroPC	\$433 - \$640
GPD P2 Max	\$800 - \$1,200
One-Netbook OneMix3	\$800 - \$1,670
GPD Win 3	\$1,100 - \$1,550
Aya Neo	\$1,015
OneXPlayer Handheld PC	\$1,000 - \$1,600
One-Netbook OneGx1	\$1,100 - \$1,500
GPD Win Max	\$2,100

*These were the approximate price ranges of each model at the time of writing, depending on specification.

THE GAMES OF 2022

What's coming to PC in 2022? Christian Guyton breaks down all the games we can expect to see next year.

2021 has been a mixed year for PC gaming, with standout hits such as *Deathloop* and *Resident Evil Village* almost drowned out by a sea of mediocre titles and endless delays and cancellations. Happily, 2022 looks like being a more exciting year, with a whole host of original games and sequels on the way. Many of these upcoming releases have been in the works for a long time, including *Starfield* (the concept work for which began way back in 1997) and *Elden Ring*, the latter of which has been on many a gamer's mind for years. Yes, we know George RR

Martin is involved. Hopefully, the game comes out before *The Winds of Winter*.

Some of these games don't have official release dates yet, so we've limited our list to titles that are confirmed releases in 2022—delays notwithstanding! We've included a broad range of games from different genres and publishers but, of course, you can expect the usual suspects to crop up in 2022; we'd be shocked if there wasn't a *Call of Duty* or *FIFA* release. So, here are the 22 games we're most excited to play on PC in 2022.



MARVEL'S MIDNIGHT SUNS *Release Date: March 2022*

Confusingly based on the Marvel comic series *Rise of the Midnight Sons* (yup, Sons rather than Suns), this is potentially the most interesting superhero game coming to PC next year. An *XCOM*-esque strategy title from genre veterans Firaxis, *Midnight Suns* features a customizable protagonist named 'The Hunter', who will join up with a selection of Marvel heroes including Wolverine, Iron Man, and Ghost Rider. Intriguingly, the turn-based gameplay is supported by card-based mechanics, with your deck influencing what abilities you can use on each mission. In classic *XCOM* fashion, you'll manage a home base called the Abbey between expeditions.

» DEVELOPER: FIRAXIS » PUBLISHER: 2K GAMES

THE LORD OF THE RINGS GOLLUM

Release Date: 2022

Why *LOTR*'s resident gremlin gets his own game is beyond us, but it's coming in 2022 nonetheless. A stealth platformer from Daedalic Entertainment, Gollum follows the titular hero's life prior to the events of the original trilogy, as he hunts down his 'precious' – that's the One Ring. Gollum is no fighter, so being sneaky and smart is the order of the day, whether you're luring an orc into a trap or creeping past a group of war beasts. One interesting mechanic is Gollum's split personality: Smeagol, the hobbit he once was, still exists within him, and your gameplay decisions will influence which side comes out on top.

» DEVELOPER: Daedalic Entertainment » PUBLISHER: Daedalic Ent., Nacon

TINY TINA'S WONDERLANDS

Release Date: 25th March 2022

A Dungeons & Dragons-themed spinoff from the *Borderlands* series, this is more of the same co-op shooting fare, set in a vibrant fantasy world, where grenades are replaced with spells and players can wield melee weapons for the first time. *Wonderlands* is the first game in the series to let players create a character rather than choosing pre-existing protagonists.

» DEVELOPER: Gearbox Software » PUBLISHER: 2K Games

ARK 2

Release Date: 2022

Despite the sizeable active player base of *Ark: Survival Evolved*, developer Studio Wildcard is pushing ahead with a second game, promising bigger and better things for the dinosaur-packed sandbox game. Somewhat unexpectedly, the sequel will feature Vin Diesel in a starring role, as the actor is apparently a huge *Ark* fan. Players can expect a more robust story this time around, as well as plenty of the same dino-taming antics offered by the original.

» DEVELOPER: Studio Wildcard

» PUBLISHER: Studio Wildcard



FORSPOKEN

Release Date: Autumn 2022

This action-adventure title from Luminous Productions tells the story of Frey, a girl transported to the fantasy land of Athia via a good old-fashioned magic portal. Frey has a few magical powers, from blasts of fire and ice to incredible speed, to navigate Athia's open world. Frey can sprint and leap fluidly through ruined towns and dark forests as she journeys to save Athia from an evil dictator.

» DEVELOPER: Luminous Productions » PUBLISHER: Square Enix

WARHAMMER 40,000: DARKTIDE

Release Date: Autumn 2022

From the developers of the excellent *Warhammer: Vermintide* series, *Darktide* takes us to the depths of the hive city of Tertium, where four players battle for survival against hordes of ghastly monsters. It's a side-step into sci-fi for *Vermintide*, offering the same co-op experience enhanced by a new setting and what Fatshark calls 'deep and balanced gunplay'. *Warhammer 40,000*'s universe is peak grimdark science-fiction, a violent dystopian setting that provides the perfect backdrop for *Darktide*'s brutal combat.

» DEVELOPER: Fatshark

» PUBLISHER: Fatshark



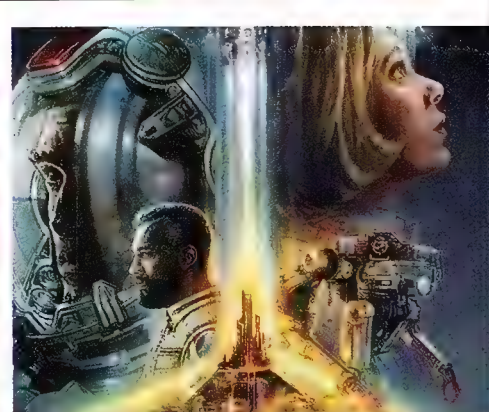


SIFU

Release Date: 22nd February 2022

One of the most interesting original IPs on this list, *Sifu* tells the tale of a young kung fu master on a journey of revenge and redemption. Hand-to-hand combat is the core of this game: martial arts techniques and brutal takedowns flow together in a symphony of violence, backed by a simple but clean cel-shaded art style. The setting is a visually distinctive neon urban backdrop, and surrounding environments offer plenty of room for improvisation: pick up a brick and throw it to briefly incapacitate an enemy, or grab a broken bottle to use as a makeshift weapon.

» DEVELOPER: Sloclap » PUBLISHER: Sloclap



STARFIELD

Release Date: 11th November 2022

Starfield is the first new IP from Bethesda in a quarter of a century. Set 300 years in the future, it casts you as a spacefaring explorer working for a group named Constellation. You are tasked with braving the depths of space through a combination of role-playing, on-foot action sequences, and combat missions.

» DEVELOPER: Bethesda Game Studios

» PUBLISHER: Bethesda Softworks



SLIME RANCHER 2

Release Date: 2022

Slime Rancher was a sleeper hit from 2017, its brightly-coloured gameworld concealing plenty of ranch-management depth as you collected and bred a variety of charmingly jiggly blobs. This sequel sees protagonist Beatrix journeying to a distant island to discover new breeds of slime. Expect more of what made the first game great: exploring, puzzling, and hoovering up hordes of slimes with Beatrix's vacuum gun before depositing them in corrals back on the farm.

» DEVELOPER: Monomi Park

» PUBLISHER: Monomi Park

THE OUTLAST TRIALS

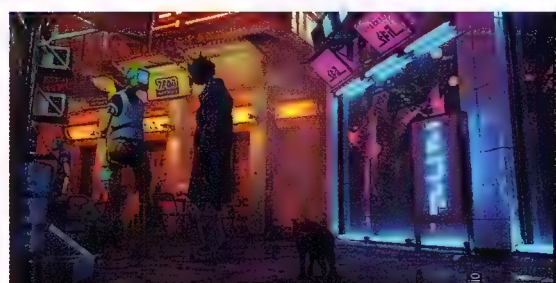
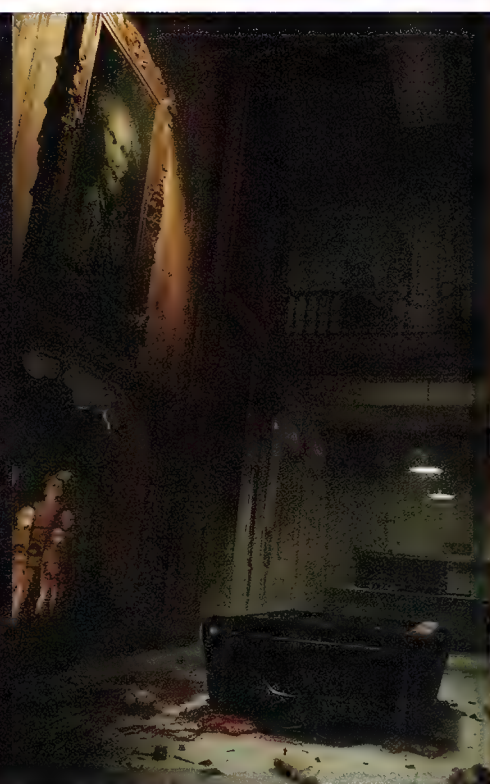
Release Date: TBA

The third installment in the *Outlast* series, this prequel takes us back to the Cold War to struggle for survival in a harrowing medical experiment. The survival-horror gameplay on show here is familiar, but new to the series is co-operative multiplayer, where up to four players can work together to escape from a number of sadistic trials. It has all the horror tropes you could wish for: creepy puppets, abandoned laboratories, and haunted fairgrounds.

As the game's description on Steam says, "It's better to sh*t your pants with friends."

» DEVELOPER: Red Barrels

» PUBLISHER: Red Barrels



STRAY

Release Date: Early 2022

You play as a cat in a cyberpunk city populated by robots – no, we can't make it sound any cooler than it already is. *Stray* looks gorgeous, with a setting inspired by the iconic Kowloon Walled City. You'll be navigating platforming levels and solving puzzles as our fearless feline hero. The city's robot denizens with their TV-screen heads make for a distinctive aesthetic.

» DEVELOPER: BlueTwelve Studio

» PUBLISHER: Annapurna Interactive

DYING LIGHT 2: STAY HUMAN

Release Date:
4th February 2022

The original *Dying Light* was a flawed but fun first-person zombie slayer, and a 20-year gap brings new zombie types and a fresh protagonist. The parkour elements of the first game return, with over 3,000 unique animations. A grappling hook and paraglider open up opportunities for escaping and ambushing the undead, and a crafting system allows you to build weapons. *Stay Human* also features a four-player co-op mode.

» DEVELOPER: Techland
» PUBLISHER: Techland



S.T.A.L.K.E.R. 2: HEART OF CHERNOBYL

Release Date: 28th April 2022

This hotly-anticipated installment of the *S.T.A.L.K.E.R.* series is set in the Chernobyl Exclusion Zone in Ukraine, where radiation has created terrifying mutants and physics-breaking anomalies. A first-person shooter with horror and survival game elements, the aim is to venture into the depths of the Zone in search of valuable artifacts with paranormal powers.

» DEVELOPER: GSC Game World » PUBLISHER: GSC Game World

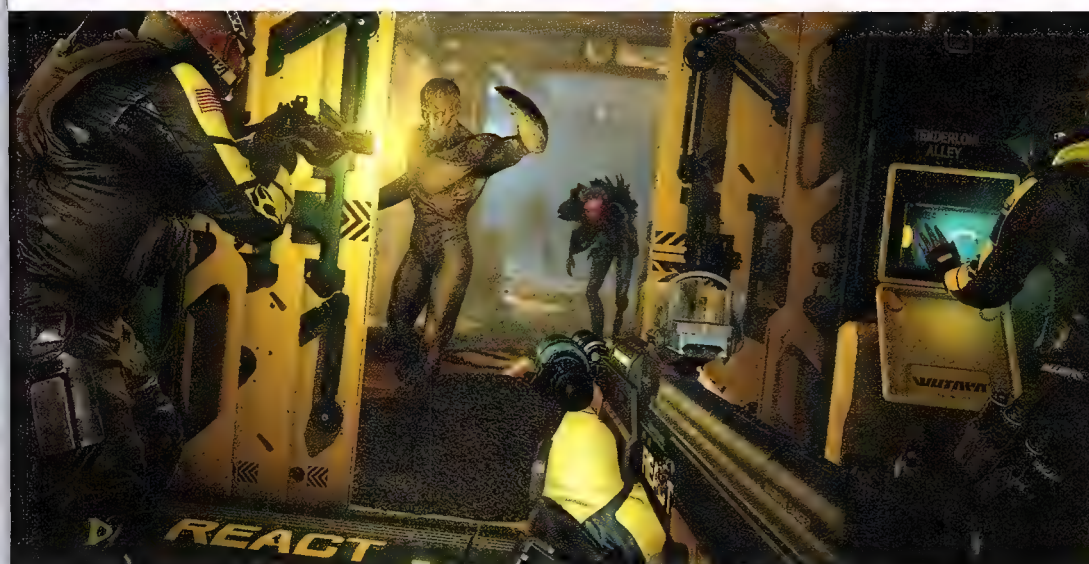


TOM CLANCY'S RAINBOW SIX EXTRACTION

Release Date: January 2022

A spin-off of multiplayer shooter *Rainbow Six Siege*, *Extraction* takes its predecessor's spec-ops heroes and throws them into a sci-fi survival scenario, where players fight bloodthirsty hordes of parasitic aliens. Elements of *Siege* remain, such as using drones to recon areas and destroying walls to create new pathways through levels.

» DEVELOPER: Ubisoft
» PUBLISHER: Ubisoft



REDFALL

Release Date: 2022

Following the success of *Deathloop*, Arkane Studios is looking to new horizons with *Redfall*, a stylised open-world shooter with co-op multiplayer that sees players take on the role of one of four vampire-hunters. With a slick animated trailer introducing our wisecracking heroes, Arkane knows how to handle character design. The four characters each have unique abilities, and collecting and upgrading weapons will be a core part of the gameplay experience. This is a *Borderlands*-type game from the developers of *Dishonored*, which sounds pretty cool.

» DEVELOPER: Arkane Studios
» PUBLISHER: Bethesda Softworks



A PLAGUE TALE: REQUIEM

Release Date: 2022

A sequel to the award-winning *A Plague Tale: Innocence*, this action-adventure title sees protagonists Amicia and Hugo on the run as the Black Death ravages 14th-century France. The sequel delves into supernatural themes, with a 'terrifying curse' following the sibling. Expect to see a lot of plague-ridden rats

» DEVELOPER: Asobo Studio
» PUBLISHER: Focus Home Interactive





BALDUR'S GATE III

Release Date: 2022

Baldur's Gate is an RPG series set in the Dungeons & Dragons universe, spawning many spin-offs and setting the bar for fantasy role-playing games. This long-awaited third entry shifts the focus from hack-and-slash to turn-based combat, but keeps the deep character customisation and branching narrative elements. An early-access release is already available on PC, its launch causing technical issues on Steam due to unexpectedly strong sales. The complete game will feature a gameworld five times larger than what is currently available, with over 16 playable races and an expected 12 character classes to choose from.

» DEVELOPER: Larian Studios

» PUBLISHER: Larian Studios



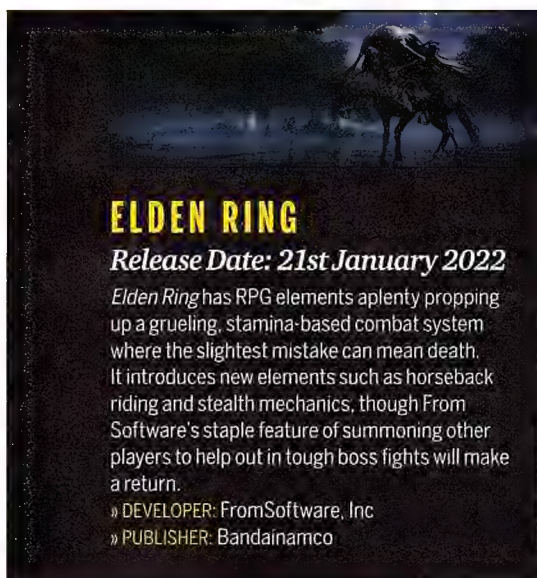
KERBAL SPACE PROGRAM 2

Release Date: 2022

Despite the silly nature of *Kerbal Space Program*, the developers have worked with astrophysicists to ensure it is the most 'realistic' spaceflight sim possible. New features include interstellar travel, colony-building, and multiplayer. We can't wait to crash another rocket into the moon.

» DEVELOPER: Intercept Games

» PUBLISHER: Private Division



ELDEN RING

Release Date: 21st January 2022

Elden Ring has RPG elements aplenty propping up a grueling, stamina-based combat system where the slightest mistake can mean death. It introduces new elements such as horseback riding and stealth mechanics, though From Software's staple feature of summoning other players to help out in tough boss fights will make a return.

» DEVELOPER: FromSoftware, Inc

» PUBLISHER: Bandainamco

OXENFREE II: LOST SIGNALS

Release Date: 2022

Oxenfree II delivers more of the same creepy, decision-based narrative excellence offered by the first game, with a new setting and protagonist. Environmental researcher Riley Poverly returns to her hometown of Camena to investigate a series of electromagnetic anomalies, only to become embroiled in a ghost story. The original *Oxenfree*, released in 2016, featured time-loops and malevolent spirits alongside amusing teen drama, so we can't wait to see what direction this sequel goes in.

» DEVELOPER: Night School Studio

» PUBLISHER: MWM Interactive



TOTAL WAR: WARHAMMER III

Release Date: 2022

The latest entry in the series takes the setting to the terrifying Realm of Chaos and introduces new factions and units. Gameplay-wise, we can expect the same complex real-time strategy content, overhauled with new mechanics and updated graphics. Developer Creative Assembly has stated that a chunk of content from the first two games will carry over to this threequel, so don't fret if you've already spent your hard-earned cash unlocking playable races in those games.

» DEVELOPER: Creative Assembly » PUBLISHER: SEGA, Feral Interactive



GOTHAM KNIGHTS

Release Date: 2022

With the Arkham trilogy officially concluded, WB Games Montreal looks set to continue the trend of open-world beat-em-ups set in the DC universe. In *Gotham Knights*, players take control of Robin, Nightwing, Batgirl, or Red Hood in a lawless Gotham City. Two-player co-op is on the table, along with a wider range of combat abilities. The villains of the piece are the Court of Owls, an iconic group from Batman lore.

» DEVELOPER: WB Games Montréal

» PUBLISHER: Warner Bros. Interactive Entertainment

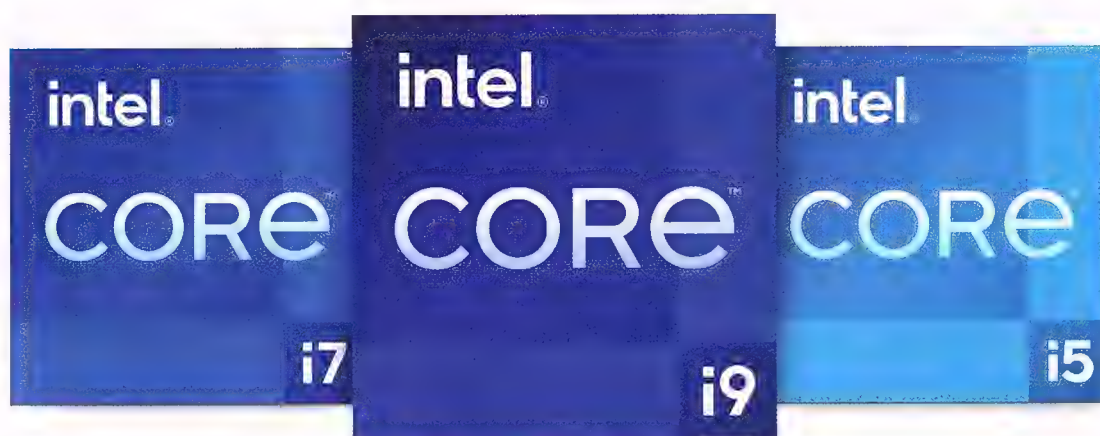
gamesradar+

One-stop destination for games, movies, TV, and more!



New Channels: Movies, TV and Cool Stuff!

www.gamesradar.com



System news

Mark Williams sits down to watch the latest episode of the Core Wars: Intel Strikes Back.

Intel has finally done it. Six years after introducing its last truly new microarchitecture in 2015 with Skylake, Intel – up against tough competition from AMD – has finally built something new from a clean slate. Alder Lake – the codename for Intel's new microarchitecture, which will provide the foundation for new products for at least the next five years – is an impressive achievement and an ingenious take on how to offer more multithreaded performance to users.

It's been a long road since AMD broke the chains of quad core CPU offerings by using its game-changing chiplet technology. Just three years after launching its Zen microarchitecture, AMD is now offering products with more than ten-fold the core count on a

consumer platform (like the Threadripper 3990X with 64 cores). By thinking outside the box, AMD's many core capability gave it the ability to compete with Intel in a way that Intel couldn't fight back against directly.

And while Intel is yet to employ its own chiplet competitor technology (tiles using EMIB technology) Intel has taken inspiration from AMD's playbook. Where AMD avoided having to beat Intel at its own game of monolithic CPU design by changing the rulebook altogether with chiplet technology, so too is Intel with Alder Lake and its Big, Little core design, changing the rulebook again by positing that not all cores need to be made equal.



MARK WILLIAMS
Mark is an IT professional with a strong interest in voiding warranties.

Sure, Big, Little has been around for ages in the ARM processor space and others, but for x86 though it's a new and innovative way of tackling the issue of offering more cores to improve multithreaded performance. This lets Intel dodge trying to compete with AMD's strategy directly, while also achieving similar levels of performance on a monolithic design. Which is mighty impressive to say the least.

Alder Lake appears to have one major downside, and that is power draw. The big performance cores are extremely power hungry. How future unreleased 12th Gen non-K processors fare remains unseen; it's believed that Alder Lake's successor, Raptor Lake, will at least address this problem, if not remedy it, while also doubling the efficiency core counts.

The fact that the Intel i9 12900K can trade blows with the Ryzen 9 5950X is very impressive. To be fair the 5950X is over a year and a half old now and AMD has Zen 3D and Zen 4 products coming early and later next year respectively, so the fight for the x86 crown in the ongoing core wars will continue at breakneck speed.

And that's the most important thing for you, the customer. With competition so strong we've seen multiple CPU generation launches over the past couple of years offer high double-digit IPC and performance increases over previous generation parts, and the projections for CPU products from both parties out to 2025 at least are going to continue that trend. We're living in a new golden age of x86 CPU design, and we're better off for it. ■

SHOP TALK

What are your thoughts on Intel's 12th Gen CPU range launch? Is customer demand strong? How are stock levels holding up?

Jaimie, Leader Computers: "We are seeing a lot of interest in the 12th Gen platform, but availability so far has been an issue, with very little stock actually hitting the channel, and DDR5 availability also testing friendships. Hopefully by the time this goes to print that will have eased a bit.

The performance looks like a big improvement from the last few iterations, it's great for consumers as it keeps pricing lower, in theory at least. Motherboards are easiest [to source], CPU and RAM are about the same difficulty at this stage, so supply is not fantastic.

Richard, Aftershock PC: "We have found customer demand to be solid but not overly strong. There seems to be a distinct lack of DDR5 RAM in the market and speaking to various company reps, it doesn't look like the shortage will be sorted anytime soon. We have found that this has severely reduced the sales of the higher end units as the majority of our customers who are after higher end builds are preferring to wait for the DDR5 motherboards and RAM which hasn't arrived yet.

Stock seems to be ok for the chips and the DDR4 motherboards at the moment, but we will have to wait and see what happens as Black Friday and Christmas come along. I have a feeling stock will become quite restricted pretty quickly."

Market snapshot

A sampling of PC systems available this month.



\$1,999 – tinyurl.com/APC502MWV

MWAVE RESPAWN NINJA ESPORTS DELTA

In these rough times of high component prices, this system is the modern-day entry-level gaming system. But don't let the words 'entry-level' fool you into thinking this system is slow; with a graphics card optimised for 1080p gaming this system will happily run a high refresh rate 1080p monitor and do a decent job at 1440p as well, offering just below RTX 2070 levels of performance. The CPU is getting on now but with the correct game settings, the GPU should remain the limiting factor. Intriguingly Mwave is shipping this with an AIO water cooler. Overkill, really, given the calibre of the processor. It'll come in handy should you want to overclock. The RAM is well-matched for the processor and with 1TB of SSD space your installed game library will be happy. A good starting point for any prospective PC gamer.

CPU: AMD Ryzen 5 3600 **Cooler:** MSI Coreliquid 280MM AIO **Motherboard:** B450 Tomahawk Max II **Graphics:** MSI AMD Radeon RX 6600 Mech 2X 8GB **Memory:** T-Force Delta RGB 16GB DDR4 3200MHz **Storage:** PNY XLR8 CS3030 1TB NVMe M.2 SSD **Power Supply:** Phanteks P300A **Case:** Cooler Master Masterwatt 650.



\$2,999 – tinyurl.com/APC502PLE

PLE COMPUTERS WOODLAND 6700 XT

Aiming for the balanced sweet spot of price and performance this system is mostly on target. The case and power supply are good quality parts giving the system an air of luxury. Setting off that feeling is the X570 motherboard, which isn't really the best choice for bang-for-buck, but as it's one of Asus' lower tier X570 boards it helps sell the quality of the system with the extra connectivity that X570 offers over B550 without breaking the bank. The CPU and GPU in this system is a well-matched combination for each other. The minor downside of this system is the memory and SSD. At 3,000MHz the RAM is well down on the 3,600MHz that the 5600X prefers to be paired with for best performance, and the SSD at 500GB, while satisfactory, will start to feel cramped quickly.

CPU: AMD Ryzen 5 5600X **Cooler:** ID-Cooling ZoomFlow 240X 240mm AIO **Motherboard:** Asus TUF Gaming X570-Plus WiFi **Graphics:** Asus Radeon RX 6700 XT TUF OC 12GB **Memory:** Gell 16GB Kit DDR4 Super Luce RGB Sync 3000MHz **Storage:** WD Blue SN550 500GB NVMe M.2 SSD, Seagate BarraCuda 1TB HDD **Power Supply:** eVGA, SuperNOVA GA 750W **Case:** Corsair 4000D.



\$4,699 – tinyurl.com/APC502PCC

PC CASE GEAR AIRFLOW 3070 TI

If you like being on the cutting edge of computing technology, but don't want to pay and arm and a leg for it, this system is a nice choice, with PCIe 5.0 support while also getting a CPU that as far as games go is basically as fast as the 12900K. The powerful 750W power supply and 240mm AIO water cooler will keep things in check. As Intel's 12th gen series supports both DDR4 and DDR5 it gives customers options, and the DDR4 used in this system is great for keeping the price in check. Best of all for gaming it isn't noticeably slower at all to DDR5 optioned systems. If you're a dedicated gamer that can occasionally make use of the extra cores this processor offers, this system will be hard to look past.

CPU: Intel Core i7 12700KF **Cooler:** Cooler Master MasterLiquid ML240R ARGB 240mm AIO **Motherboard:** Asus TUF Gaming Z690-PLUS Wi-Fi D4 **Graphics:** Asus GeForce RTX 3070 Ti TUF Gaming OC 8GB **Memory:** Team T-Force Delta RGB 32GB 3600MHz DDR4 **Storage:** PNY CS3040 M.2 NVMe Gen4 SSD 1TB, Seagate BarraCuda 2TB HDD **Power Supply:** Super Flower Leadex III Gold 750W **Case:** Phanteks Eclipse P500A Airflow D-RGB.

\$6,999 – tinyurl.com/APC502SCO

SCORPTEC VENGEANCE RTX 3080 TI

If you're after the best of the best this system is hard to look past. Sporting a CPU that matches AMD's 16-core Ryzen 9 5950X, while being faster in gaming scenarios, this system is a beast for those that can make use of it, or at least don't mind paying the extra price premium to get in early on DDR5 as well as PCIe 5.0. With 24-threads available on the CPU and 32GB of DDR5 RAM this system is geared more to high-powered users who use heavily threaded productivity applications often. Matched with a generous 1TB SSD and 4TB HDD storage, you'll have ample room for most data crunching needs. The 1000W PSU is very welcome in this high-power consumption build with both CPU and GPU being power hungry monsters. A very nice system that can do it all, gaming or productivity, that should only be considered by power users or professionals with CPU heavy workloads.

CPU: Intel Core i9 12900KF **Cooler:** Corsair iCue H150i RGB Pro XT CPU Cooler **Motherboard:** Gigabyte Aorus Z690 Master **Graphics:** Gigabyte Gaming GeForce RTX 3080 Ti OC 12GB **Memory:** Corsair Dominator Platinum RGB 32GB 5200MHz DDR5 **Storage:** Seagate FireCuda 520 1TB M.2 SSD, Seagate BarraCuda 4TB HDD **Power Supply:** Corsair RM1000x 1000W **Case:** Corsair iCue 5000D Airflow. ■



PC BUILDER

Budget

A perfect balance between price and performance.

Intel's budget build this issue has seen quite the shakeup. We see three initial swaps. Thanks again to a sale, we can slot in a Samsung 980 500GB SSD into the budget machine here, which is always a nice sight. Matching last issue's Crucial SSD in price, we feel it's certainly worth it.

Another change is our motherboard; we switched this out from Asrock's B460M Steel Legend to MSI's B460M PRO-VDH WIFI model. This change saves us \$31.

CPU stocks for Intel are more stable so, thankfully, we have no shortage for our budget Intel build again. The Intel Core i3-10100 still stays here, with its price holding steady. Sure, it's almost two generations old, with the release of the 12th-gen Alder Lake chips but, for a budget machine, the performance is all that you will need. Another slight performance increase, though, for the Intel side is the 16GB of Crucial Ballistix CL16 RAM. This has a speed of 3600MHz, 400MHz greater than the previous Crucial Ballistix sticks we had.

These RAM sticks also find their way into the AMD build, taking the speed up from 3200MHz to 3600MHz. Along with this change, a new chip is introduced to the AMD side, the Ryzen 5 3600. Our previous Ryzen 3 3100 is out of stock and, at \$120 more, this is an upgrade worth doing. With six cores instead of four and also an extra four threads, this CPU seems like a worthwhile swap on paper.

With this 3rd-gen chip and motherboard supporting PCIe 4, the PNY

SSD is swapped out on the AMD build for an XPG S50 Lite SSD, which is coming back into stock in Australia. We thought about swapping it out for the Samsung 980 found on the Intel side, but that is only PCIe 3.0. The standard hard drive storage and PSUs on both budget builds for this issue. One last thing to mention is the dreaded GPUs. Yes, still overpriced on the second-hand market and near enough impossible to buy new.



AMD INGREDIENTS

PART		PRICE
CASE	Corsair 4000D Airflow	\$130
PSU	500W EVGA BA 80+ Bronze	\$70
M/BOARD	Asrock B550 Phantom Gaming 4/ac AM4 NEW	\$130
CPU	AMD Ryzen 5 3600 NEW	\$330
GPU	AMD Radeon RX 6700 XT 12GB	\$1,200
RAM	16GB (2x8GB) Crucial Ballistix CL16 @ 3600MHz NEW	\$220
SSD	512GB XPG GAMMIX S50 Lite PCIe 4.0 M.2 SSD NEW	\$130
HDD	1TB WD Blue 1TB 7200	\$60
OS	Windows 10 Home 64-bit OEM	\$60
PRICE		\$2,330

INTEL INGREDIENTS

PART		PRICE
CASE	Corsair 4000D Airflow	\$130
PSU	500W EVGA BR 80+ Bronze	\$90
M/BOARD	MSI B460M PRO-VDH WIFI Micro ATX LGA1200 NEW	\$109
CPU	Intel Core i3-10100	\$190
GPU	Nvidia GeForce RTX 3060 12GB	\$1,150
RAM	16GB (2x8GB) Crucial Ballistix CL16 @ 3600MHz NEW	\$220
SSD	500GB Samsung 980 NVME M.2 PCIe 3.0 SSD NEW	\$90
HDD	1TB WD Blue 1TB 7200	\$60
OS	Windows 10 Home 64-bit OEM	\$60
PRICE		\$2,099



PC BUILDER

Mid-range

A very much game-ready machine, ready for demanding regular work, too.

Starting with some of the more basic parts on these two mid-range builds, we have the same PSUs being introduced. These are Corsair's 650W RM 80+ Gold power supplies, which provide more than enough power for both of these builds. Another part we see in both machines is an increase from 1TB of HDD to 2TB with WD's Blue 7200 drive hitting a nice price of just \$78 for a generous and useful 2TB. The CPUs on each build also remain

unchanged. Pricing is fair and holding steady for almost all CPUs on the market now. We only wish graphics cards could return to sanity pricing and availability the same way CPUs have.

GPUs also drive us mad. You can pick up some 3070s for a minimum of \$1,700, but that's criminal. The same goes for the Radeon RX 6800 XT GPU, which starts at an even heftier \$1,750. In slightly better news, we have a few price changes for the AMD build. The trusty

Asus TUF Gaming X570 motherboard is still a great board and is made even better by being \$31 cheaper than last month, thanks to a sale at Scorptec.

For Intel's RAM, we have swapped out the Kingston FURY Renegades for some Corsair Vengeance sticks. These are running at the same speed (3600MHz) and give us some RGB. We had to swap these out as, at the time of writing, we couldn't find any of the Fury Renegades that ran at 3600MHz, only 3200MHz.

AMD INGREDIENTS

PART		PRICE
CASE	Lian Li PC-O11-Dynamic	\$210
PSU	650W Corsair RM (2019) 80+ Gold NEW	\$159
M/BOARD	Asus AM4 TUF Gaming X570 -Plus WiFi	\$299
CPU	AMD Ryzen 5 5600X	\$449
COOLER	240mm Cooler Master Masterliquid ML240 RGB	\$149
GPU	Nvidia GeForce RTX 3070 8GB	\$1,700
RAM	16GB (2x 8GB) Team Vulcan Z CL18 @ 3600MHz	\$140
SSD	500GB Samsung 980 Pro NVME M.2 PCIe 4.0 SSD	\$170
HDD	2TB WD Blue 7200 HDD NEW	\$78
OS	Windows 10 Home 64-bit OEM	\$60
PRICE		\$3,414

INTEL INGREDIENTS

PART		PRICE
CASE	Lian Li PC-O11-Dynamic	\$210
PSU	650W Corsair RM (2019) 80+ Gold NEW	\$159
M/BOARD	Asrock Z590M PRO4	\$230
CPU	Intel Core i7-11700K	\$599
COOLER	240mm Cooler Master Masterliquid ML240 RGB	\$149
GPU	AMD Radeon RX 6800 XT 16GB	\$1,749
RAM	16GB (2x 8GB) Corsair Vengeance RGB Pro SL RGB CL18 @ 3600MHz NEW	\$149
SSD	500GB Corsair Force MP600 M.2 PCIe 4.0	\$149
HDD	2TB WD Blue 7200 HDD	\$78
OS	Windows 10 Home 64-bit OEM	\$60
PRICE		\$3,532



PC BUILDER

Turbo

The maximum PC.

Last time around, it worked out better for both turbo builds that we chose two 3TB hard disk drives from Western Digital as this was cheaper than buying one 6TB HDD. However we're changing now to a single Western Digital's Blue 6TB HDD for almost the same price. If anything just to keep our imaginary build tidy inside. For our main storage, we have stuck with the same speedy PCIe 4.0 SSD's for both Intel and AMD Turbo builds. These are great drives, both with 1TB of storage. On the AMD turbo machine, the price of the Samsung 980 Pro seems to have stabilised, and is a nice \$30 cheaper this time. The Gigabyte Aorus Gen4 7000s SSD for the Intel PC price hasn't, but nor is it more expensive.

The big change for the AMD rig is a

swap of motherboards. Out goes the MSI MPG X570 Gaming Edge Wi-Fi and in goes Gigabyte's X570 Gaming X. MSI's board is \$30 more expensive than Gigabyte's alternative. Both are great boards, but we are sticking with the more sensible choice for now. Over on the Intel build, MSI's MAG Z590 Tomahawk has crept up in price a little, but not enough to warrant a change.

Not many changes have been made on the Turbo builds overall. We can't wait to add Alder Lake chips to our top-tier Intel build but, for now, we're sticking with the monster Intel Core i9-11900K chip. It's still one of the best Intel processors. AMD's Ryzen 7 5800X is equally impressive and deserves its spot in the AMD turbo build. At just under \$630, it is \$170 cheaper than

Intel's offering. Other than the mobo and HDD, everything else remains the same for team AMD, though Corsair's iCUE H150i Elite Capellix AIO 360mm has fallen by a very welcome \$50.

On the Intel rig, there was just one alteration, other than the HDD. The Fractal Design Ion PSU from the previous issue was becoming difficult to find, resulting in a change to Corsair's RM (2019) falling into the machine. It made sense to fit it in, even though this is far from the budget build. Last but not least, GPU issues. Yes, we sound like a broken record, but we can't recommend paying the extra. It's your decision, of course, but at more than double the RRP, that makes us quake in our boots. ■

AMD INGREDIENTS

PART		PRICE
CASE	Phanteks Enthoo Pro 2 Tempered Glass	\$210
PSU	750W Nxt C750 80+ Gold	\$139
M/BOARD	Gigabyte X570 Gaming X NEW	\$230
CPU	AMD Ryzen 7 5800X	\$629
COOLER	Corsair iCUE H150i Elite Capellix AIO 360mm	\$219
GPU	Nvidia GeForce RTX 3080 10GB	\$2,500
RAM	32GB (2x 16GB) G.Skill Ripjaws V 32GB @ 4000MHz	\$399
SSD	1TB Samsung 980 Pro M.2 PCIe 4.0	\$249
HDD	6TB WD Blue 5400 HDD NEW	\$225
OS	Windows 10 Home 64-bit OEM	\$60
PRICE		\$4,860

INTEL INGREDIENTS

PART		PRICE
CASE	Phanteks Enthoo Pro 2 Tempered Glass	\$210
PSU	750W Corsair RM (2019) 80+ Gold NEW	\$169
M/BOARD	MSI MAG Z590 Tomahawk Wi-Fi	\$299
CPU	Intel Core i9-11900K	\$799
COOLER	MSI MAG CoreLiquid 360R AIO	\$149
GPU	AMD Radeon RX 6900 XT 16GB	\$2,300
RAM	32GB (2x 16GB) G.Skill Ripjaws V 32GB @ 4000MHz	\$399
SSD	1TB Gigabyte Aorus Gen4 7000s M.2 PCIe 4.0	\$289
HDD	6TB WD Blue 5400 HDD NEW	\$225
OS	Windows 10 Home 64-bit OEM	\$60
PRICE		\$4,899



PC BUILDER MASTERCLASS

Downsizing

Going to a slightly smaller ATX chassis



ZAC STOREY

Zac is pretty good at building PCs and enjoys nothing more than a problem with no apparent solution.

Nzxt cases have long been a favorite at APC. The super-clean lines, and design language, combined with a strong price structure have cemented these cases as standout products. The only caveat has been access to cool air. Many years ago, we built an SLI-ed system in this case's forefather, the S340 Elite. It was a beast of a machine, beautiful to behold, and powerful beyond all measure. But give it a lengthy session in a graphically intense title, and after an hour or so, the processors started to throttle, and coolant temperature warnings popped up all over the place.

This has been an Achilles' heel for Nzxt ever since the company reinvented itself

with the Manta line of chassis, so to see it ditch the clean smooth panels in favour of a bolder, airflow optimised style with the latest Flow chassis was, er, a breath of fresh air. So then, what's the concept? If we take our personal computer and transplant it from the Corsair 5000D Airflow build, (complete with nine 120mm fans, 360mm premium AIO, and beefy RTX 3080), and move it into the smaller H510 Flow, would the design changes that Nzxt implemented be enough to house all that power without throttling under its own heat? Seems simple enough.



Changes upon changes

At the heart of this system lies a bit of a Frankenstein build, pieced together out of various parts from several builds that we created throughout the past year or so. The main bulk of that surrounds the Corsair 5000D 4K gaming PC we put together back in March 2021, albeit with a fair few changes on top.

The first big change comes in the form of the GPU. We dropped the AMD Radeon RX 6800 XT for an MSI GeForce RTX 3080 Suprim X. Next up was the memory, we just weren't having any luck with that 32GB (4x 8GB) Corsair Vengeance Pro memory kit, so we swapped it for the special order 64GB (2x 32GB) kit of HyperX Predator DDR4 @ 3200 MHz that we got in for our tiny Nzxt H1 Editing PC back in October 2020. And lastly, we dropped down to a single M.2 drive in the form of the PCIe 3.0 Corsair Force MP400 2TB SSD. By no means a super-speedy drive, compared what the best PCIe 4.0 has to

offer, but for our day-to-day use with this machine, it has more than enough storage and performance for everything we do. Aside from that, the motherboard, processor, case, power supply, and cooling were all identical to the 4K system (albeit we did add in one extra sleeved PCIe power cable from a separate Corsair kit for the power-hungry Suprim X GPU).

With all that in mind, and given this was a transplant system, we knew there were going to be some drawbacks when it came to downsizing into the H510 Flow's chassis. Namely the CPU cooler. Because the case only supports up to a 280mm cooler, we ditched the Corsair H150i Elite and instead opted for another Frankenstein part, the be quiet! Silent Loop 2 240mm AIO from our Raijintek Retro build back in our August edition of 2021, all of which would be supported with six of the Corsair QL120 fans from the 4K build to top it off (for maximum internal and external lighting).

DOWNSIZING INGREDIENTS

PART		PRICE
CASE	Nzxt H510 Flow	\$160
MOBO	Asus ROG Crosshair VIII Dark Hero	\$750
CPU	AMD Ryzen 9 5950X	\$1,100
GPU	MSI GeForce RTX 3080 10GB Suprim X	\$2,700
MEMORY	64GB(2x32GB) HyperX Predator DDR4 @ 3200	\$460
PSU	750W Corsair CXF 750W 80+ Bronze	\$140
PRIMARY STORAGE	2TB Corsair MP400 Force PCIe 3.0 M.2 SSD	\$350
CPU COOLER	be quiet! Silent Loop 2 240	\$180
FANS	6x Corsair iCUE QL120	\$270
OPERATING SYSTEM	Windows 10 Home 64-bit OEM	\$60
TOTAL		\$6,170



01 Deconstruction

The 5000D Airflow has been a fantastic choice for a chassis for this 4K build. Its only drawback (as long-time readers will know, we tend to lean on the smaller side of PC building life) is that it's a big, solid unit. Now that could be a positive, it certainly makes it easier to build in and easier to cool, but as our systems are typically something we want to show off, it's less than convenient placing it on a desk.

Thus the conundrum. Ours has sat underneath a 2.7m long desk for well over half a year at this point, where it's just sucking up dog hair and dust perpetually. So removing all of the kit and migrating it into a smaller chassis that we can put on top of the desk, without it looking too out of place, is the perfect call.



02 Frankenstein's monster

A lot of different parts are going into this build from the original setup, but the one thing we can't take across is the cooling. Sadly, the H510 tops out at a single 280mm AIO and, as such, we need to pick out a new cooler. We decided on the Silent Loop 2 for a number of reasons. It's really easy to install on an AMD socket. The pump is insanely quiet, and honestly, we quite like the design. One thing we won't be taking with us is the two be quiet! fans. Instead, we'll be using the Corsair QL fans that we built with during the 4K build, but doubling up, and attempting to configure a push-pull configuration (basically having two fans on one side pushing air through the radiator, and another two on the opposite side pulling), but more on that later.



03 Why no AMD GPU?

So why did we swap from the RX 6800 XT? For convenience, mainly. The card was needed for another build later in the year, and so we pulled it out on the day of the shoot, went into the office, built a machine with it (the G.Skill Z5i system), and then grabbed a replacement card to fit in the PC at home, while the Z5i was being tested with the 6800 XT. It really is that simple. Such is the life of a tech journo, perpetually swapping parts.

Performance deltas between the two are fairly negligible, some games are better optimised to AMD (eg. *Assassins Creed: Valhalla*), others are better suited to Nvidia (any with ray tracing). One thing we would point out is that the Suprim X is massive and requires three 8-pin PCIe power cables as standard. We will run into problems with this later down the line, too.



04 Go with the flow

Nzxt's flow is perhaps the best implementation of an airflow style chassis we've seen to date. At least from a style perspective, anyway. Those front perforations are large, impressive, and it's super-slick and super-clean. You still have the square panels, tempered glass, PSU covers, cable tidies, and everything you'd find in a standard 510, but without the solid front panel.

The front panel itself is a bit more solid than the Corsair case we used for the build-off in the previous issue, and it has a fairly fine dust filter magnetised into the front of it. You can remove it for cleaning, but it is a bit of a tight fit in the panel itself and can be a bit troublesome to get back in once you have cleaned it.

Once the fans are installed, there is about an inch of space between the fans and the front filter too.



The home of technology

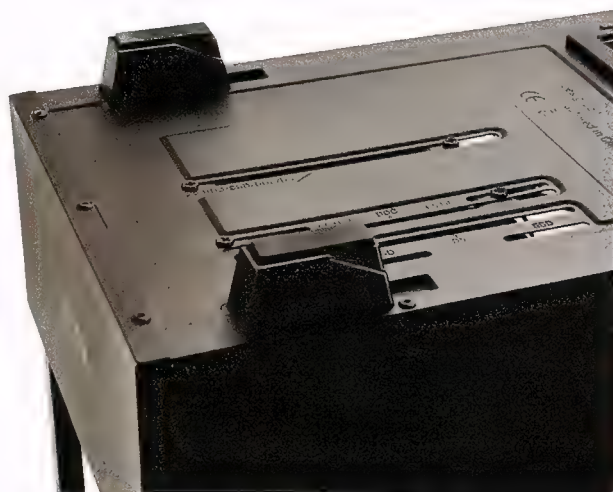
techradar.com



05 Light show

This is one of those form-over-function choices we often have to make here at *APC*. Let's be clear, these are awesome fans with some seriously cool lighting effects, but they aren't entirely the best at cooling radiators. You know how some people buy cars with large V8 engines that sound great but aren't particularly fuel efficient? It's a bit like that. We know they look awesome and that they will fit the build well, but they're no Noctuas, that's for certain.

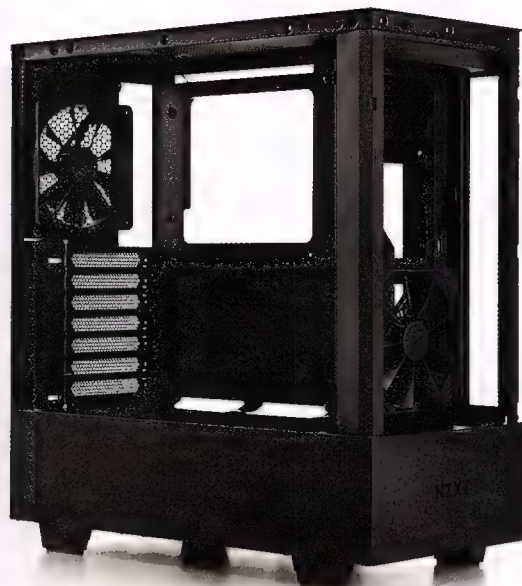
For stats, they pump out a fairly reasonable pressure of 1.55 mmH2O and can shift just under 42cfm of air too. They're not cheap either, with a triple pack setting you back \$135. For that, you get the three fans plus a separate RGB controller (although we're cannibalising something for that a little later). Ouch!



07 HDD cage removal

To give ourselves a bit more space in the bottom of the chassis to allow for some cable stuffing. We're going to remove the 2.5-inch/3.5-inch hard drive caddy. To do this, we pop the case on its head to allow us complete access to the bottom of it. Here, you will notice four Phillips screws securing the caddy in place.

Simply remove these four screws, and then carefully remove the cage from the side of the chassis. Just make sure the rear panel is off first and that you have a hand underneath when removing the cage so that it doesn't just drop and start rattling around the case.



06 Panel removal

Now we've got all the parts removed (and well showcased), it's time to get stripping this thing down ready for the build. The H510 Flow is a fairly easy case to take apart and the front panel pops off easily. Pull it from the rear side of the case and the two pins will pop out from the top, you can then lean it back and pull it out.

The tempered glass side panel is also fairly minimal in design. A single thumbscrew holds it in place at the top left of the panel. Undo that, then lean the window out towards you and lift out.

You will also notice that there's a radiator bracket in the front of the chassis there. You can remove this with two thumbscrews, however, we're leaving it in for the time being.



08 Motherboard install

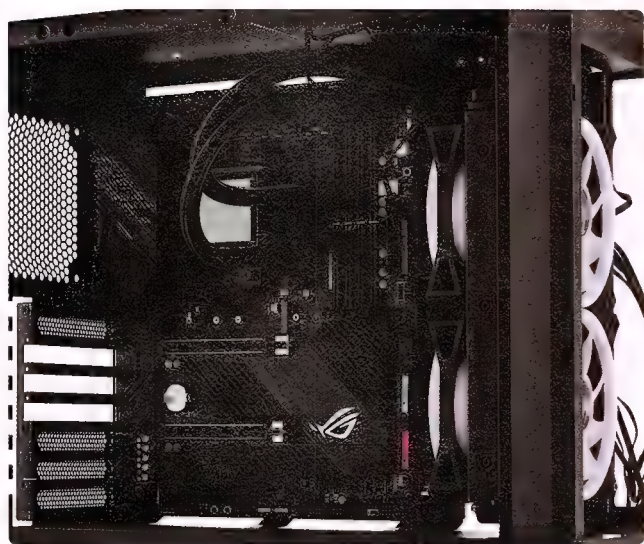
With the cage removed, we have taken the opportunity to remove the front radiator bracket and also the rear-most fan from the case. Every fan-mounting location we have here is going to be filled with a fan. As we're just transplanting this rig, there's not much in the way of legwork that needs to be done before installing the motherboard. The AMD processor is still installed in its socket, and the M.2 SSD is tucked away, hidden beneath its bottom-most heatsink. Line the board up, slot it in place, and secure it with the screws provided in the chassis accessory box.



09 Fan cable nightmares

Next up on the list is preparing the cooler for installation. As we're going to attempt to run push-pull with our configuration, we need to effectively pin the radiator to the bracket using the front intake fans. Place the fans on the outside of the bracket and the radiator on the inside, then use the slightly longer screws provided with the cooler to secure it in position from one side.

With one side complete, move on to the rear pulling fans and install them with the slightly shorter radiator screws. Fan guards will always be placed at the rear of the fan, so you can easily tell which way the air will flow. It's also worth keeping in mind your cable orientation. Try and keep them pointing towards the rear or side panel of your case.



11 CPU block attached

With the radiator installed and the fan cables threaded through into the rear of the chassis, it's time to install the block onto the processor. Luckily, as we used this cooler in our Raijintek build (also an AMD system), we had all the mounting hardware to hand.

Installation is simple enough. There are four plastic standoffs, two metal brackets, and four screws. Remove half the stock mounting bracket that comes with the board and install the be quiet! one over the top. Once secure, do the same with the top. This is a smart way to reduce fiddling about with the back bracket when the board is already in the case. That way it won't fall out, unlike if you removed both stock brackets at once.



10 Cable bar failures

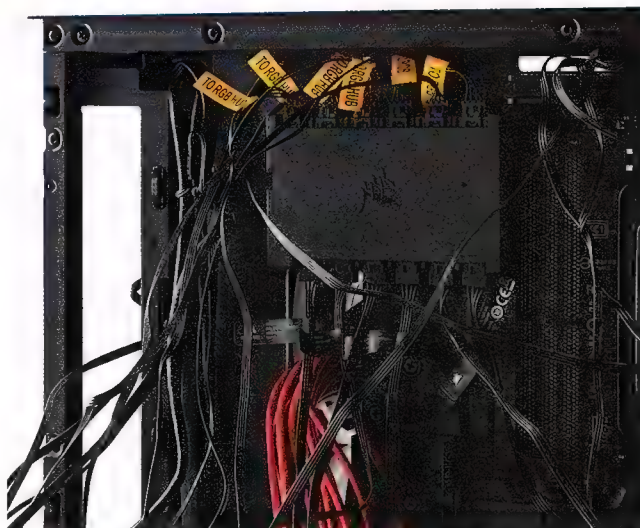
As Push-Pull is a fairly rare concept these days for AIO coolers, most manufacturers don't allow that much clearance for it in small footprint case designs like the H510 Flow. As such, with this neat cable bar installed, you can't install the radiator with fans in this configuration without conflicting with the cable bar. The only solution is to remove the cable bar, then install the radiator first. However, after trying this, the cable bar still didn't fit in place, so we removed it entirely. Removing it is a fairly easy process. Simply locate its connection points on the rear of the chassis and remove the four Phillips head screws that are holding it in place.



12 Cables, cables, cables

We knew this was immediately going to start getting a little cramped in here. So cables were next on the agenda. The two CPU power cables went in at the top left, then the motherboard's 24-pin, and the front panel connectors went in the bottom. We then installed the remaining fans in position making sure to route everything to the back of the chassis for our secret weapon.

Fitting to the top-most fan was a bit of a pain because, even though it was slightly smaller (120mm not the maximum supported 140mm), it was making contact with that right-most CPU power. After some 'gentle' encouragement (including pushing it in place really hard), finally, we managed to get it secured.



13 Corsair Command Module

Each of the fans in this build has two cables apiece – one for the fan control and the other for RGB control. On top of that, we also have one cable for the pump control. To get around this, we're pilfering the Corsair Commander unit from the 5000D build and repurposing it for this rig. It still has a bit of stick left in its double-sided tape and so that helps us organize all our fans neatly into position, sorting all six.

This is then powered by a single SATA power header and plugs in via USB to the motherboard. We're then free to install the be quiet! pump cables where they need to go. There's one dRGB header at the top of the motherboard and the pump's fan control will go directly into a PWM header also located at the top.



15 Stop sagging

This is one of the neat things about this case. Given the hefty girth of the card, it has a tendency to sag. The RTX 3000 series are seriously hot and so most of the cards' cooling solutions have been amped up to be a minimum tri-slot design. The Suprim X is no different in that regard. Because that puts an excessive amount of weight on the slot, you can end up with GPU sag, so to combat that, MSI includes this handy little adjustable stand.

Usually, these stands look really out of place and a bit ugly, but given how close to the radiator that GPU is, you can almost hide this alongside the AIO. That should reduce tension on that slot and keep our card more secure in the long term.



14 Suprim-ly Oversized

There's nothing like coming up against a problem and finding a solution. At first glance, when looking at the ridiculously long Suprim X RTX 3080 from MSI (13.2-inches or 336mm), it looked like it would just about fit in the case, with the radiator and fans running in push-pull. Looking at how the card mounted in its PCIe slot, it seemed clear that it would fit, albeit snugly.

On the first attempt it didn't, so we removed the radiator and tried fitting it first, then sliding in the radiator. Still no luck. We installed the radiator back in place and removed the bottom-most fan, intending to reinstall it later. On this attempt, we just managed it but it led to us using a tri-fan push-pull setup, rather than the full quad. Annoying! We'll save our thoughts on that for later.



16 Completed!

With the GPU finally in and the card plugged in, the system was complete, but not quite as bright as it should be. Despite having iCUE all preconfigured, thanks to a pre-installed OS (as it's a transplant system), it wouldn't load the settings and defaulted to this until a complete reinstall was performed. Why? Not a clue. Most likely it's something to do with unplugging everything from the Corsair Commander module and removing the iCUE cooler extension. This thing looks epic. Of course, it's not without its flaws but, then, no build ever is.



- 1 We've adjusted this adjustable bracket a little bit too high, so it's putting too much pressure on the GPU, and making the bar lean inwards, annoyingly.
- 2 Moving the radiator to the outside of the bracket may allow us to install that missing fan here instead.
- 3 White cables would help better reflect our light choice on the RGB setup. Neutral tones help a lot with lighting.

The conclusion

You know, as a final build, in a chassis that we didn't originally plan to build in (the latest Bitfenix Prodigy was ordered, but won't arrive until next month), this turned out to be a really fun exercise.

We've been using this rig for a few days and it's a smooth-running piece of kit. Let's talk performance because that addresses some of the pitfalls with the build process and more. The big one is the temperature. Does the H510 Flow have enough grunt in it to keep our RTX 3080 Suprim X and 5950X 16 core processor cool? Short answer: yes.

We've been doing some lengthy *Middle Earth: Shadow of War* playthroughs lately, keeping an eye on HWMonitor as we do to track GPU and CPU temperatures, and neither seems to go above 80°C at all. Now, admittedly, the card does top out at 83°C in its BIOS settings anyway, but we're nowhere near that and the CPU is pretty cozy too. There are no temperature warnings or anything of that ilk. It's a well-cooled case, and using all of the possible fan mounting locations has helped that. One thing to note, though, is that the top of the chassis gets hot – like, can't put your hand on it hot – after four hours of continuous use or so.

Aside from that, performance is as apocryphal as it always has been with this kind of combo. CineBench R15 scored a seriously impressive 4,299 in multi-core, and 262 in single-core

performance, our SSD topped out at 3,114 MB/s read and 2,938 MB/s write, and well, the RTX 3080, did what RTX 3080s do at 4K.

With that out of the way, there are a few post-build thoughts that have crossed my mind, particularly with the GPU situation and that missing fan. There may be two ways of remedying this, which we didn't perform on the day. First, we could have made better choices with our GPU. If we had gone with the RX 6800 XT, which measures just 267mm or 10.5-inches, it's a full 2.7-inches shorter than the Suprim X. Swapping that out would have allowed us to install the additional fan.

If you don't want to give up the RTX 3080, another solution might have been

to mount the entire radiator unit to the exterior of the radiator bracket. There's a good inch or so between the front intake fans and that fan filter on the front grill. Shift the entire unit so the radiator and intake fans are on the outside of the bracket and the pulling fans are on the inside, and you'd gain the clearance necessary to fit the card.

That said, it's still a sweet build. A sad reminder of what you could build if the industry wasn't currently messed up.

Whoever you are, no matter what your age, when it comes to picking your next PC, I implore you to build your own. Yes, it can be frustrating and occasionally difficult, but it's such a satisfying thing to do and well worth it, in my humble opinion. ■

	Zero point	Downsize
CineBench R15 Multi (Index)	4,278	4,299
CrystalDisk QD32 Sequential Read (MB/s)	3,995	3,114
CrystalDisk QD32 Sequential Write (MB/s)	4,199	2,938
Total War: Warhammer II (fps)	65	73
Shadow of the Tomb Raider (fps)	80	86
Red Dead Redemption II (fps)	69	77
Middle Earth: Shadow of War (fps)	72	72

Our zero point consists of an AMD Ryzen 7 5950X, 32GB of DDR4 @ 3600, an AMD Radeon RX 6800 XT, and a 1TB Corsair Force MP600 PCIe 4.0 M.2 SSD. All tests were performed at 4K on the highest graphical profile available.

Quick Tips

The problem solvers

The APC team field problems across the spectrum of devices and software. Learn a new trick or fix you can use.

Random BSODs

I'm suffering from a weird problem that I hope you can help me fix. I am getting random blue screen errors when copying or moving files, and once in a while when I open too many browser tabs. I had one when I was syncing my **Ancestry.com** family tree to Family Tree Maker, when scanning a large downloaded file with McAfee, when trying to create an OS backup with Macrium Reflect Free and even while downloading a Linux ISO to create a live disc to boot from.

This problem has existed since I built the PC in October 2020, starting when I copied files from the old computer's drives to this one. It happens when copying files from external hard drives or flash drives to internal SSDs or HDD, internal to internal, or internal to external drives.

I am pretty sure this isn't a hardware problem. I can boot to a Linux live DVD (I used PCLinuxOS) and copy or move files without any problems. And I booted to a Macrium USB flash drive and created the OS backup without problems too. Western Digital's Dashboard shows all of the internal drives to be healthy. The external drives work fine with laptops. And I have to assume the cables are OK since I can copy files without errors when booting to a USB drive or Live DVD.

Before I format and reinstall, I wondered if you could come up with anything less severe. And I am a bit skeptical that a format and reload will fix this since it started immediately with a new build and installation.

Dave Marshall

APC Responds: Seemingly random errors like this often point to faulty memory, particularly when there's no obvious pattern to when or how they occur. But first, we wanted to check the drives – not just to eliminate them as the cause of the problem, but also to ensure there weren't any problems as a result of all those crashes. Sure enough, when Dave ran Chkdsk on all the drives, errors were found and corrected. He also checked their SMART status to eliminate a rogue drive as the cause of the problem. Once done, we turned our full attention to the RAM.

Dave had already run the Windows Memory Diagnostic tool twice with no reports of errors, but we persuaded him to download and run the free version of Memtest86 from www.memtest86.com/memtest86.html as part of a more thorough check. Don't confuse the Passmark version with the open-source Memtest86+ that was forked from the original open-source project; sadly, Memtest86+ doesn't officially recognise the latest DIMMs. Sure enough, Memtest86 threw up so many errors with Dave's four sticks of 8GB Corsair Vengeance LPX DDR4-2400 CL16 RAM that it aborted the test with a big red FAIL.

Once you've identified a failure, you need to pinpoint which stick(s) of RAM are failing – Memtest86 can provide clues here. In Dave's case, it consistently reported errors in the "26G-28G of 32G" range of the installed memory. Sure enough, by isolating and testing each stick of RAM, Dave was able to confirm the faulty module was sitting in the fourth and final slot (#B2) on the motherboard.

As Dave's RAM was still under warranty, he got in touch with Corsair. It required him to test each stick independently in Memtest86 and then email the results of each scan as an HTML file. On receipt of the results, Corsair accepted the fault and authorised a return under guarantee of not just the failed DIMM but its matched pair. This ensures the replacements will be similarly matched.

Tagging issue in Plex

I recently allowed Plex to switch my TV library's scanner to its new Plex TV Agent. Since doing this, I have one of two choices: if I want to view specially tagged content (such as specials not covered by TheTVDB) then I must tick 'Prefer local metadata' under 'Manage Library > Edit... > Advanced'. However, this reveals that several of my regular TV shows have got title tags that have been added elsewhere. Where these tags exist, Plex uses these tags instead of the episode titles scraped from online databases.

So, if I untick 'Prefer local metadata', I get all the correct episode

titles, but no tagged specials, but if I tick it, I end up with incorrect episode titles for some shows. I have various tagging tools, including MetaX, but none of them seem to offer an easy way to remove existing tags, merely replace them with other tags. What's the simplest way to remove these tags? All my files are in MP4 format

Bryn Kolawski

APC Responds: The solution is closer than you think, Bryn. You can strip title metadata from MP4 files using Windows Explorer. Once you've identified a folder containing these items, select all the files inside it, right-click them and choose Properties. Switch to the Details tab where you should see the Title tag has a Value, whether that's a single title across all files or, more likely, (Multiple Values).

At the bottom, you'll see a 'Remove Properties and Personal Information' link. Click this to open a new window. Here, select 'Remove the following properties from this file' and tick Title before clicking OK. A File Explorer window will open and each file will have its tag removed and then be saved. The process can take several minutes, depending on the file size.

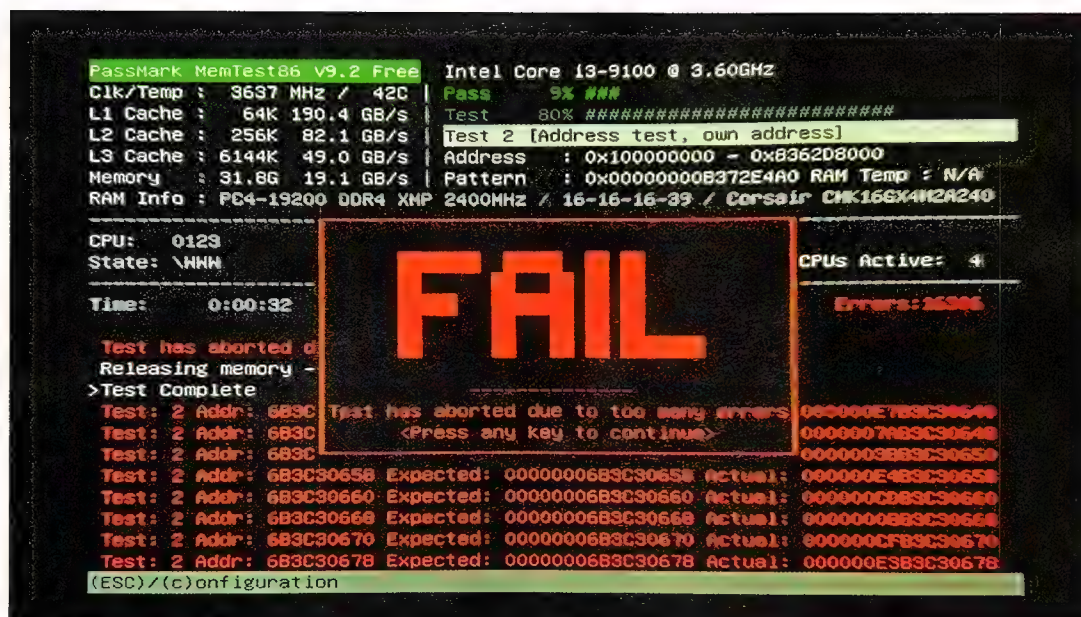
Once complete, click OK, then navigate to the TV show's entry within the Plex web interface. Roll your mouse over its artwork and click the vertical ellipsis button that pops up. Choose 'Refresh Metadata' and wait for the process to complete. Once done, navigate to the show that was displaying the wrong title and you should see it now displays the correct episode info.

Can't bypass login

I purchased and downloaded a new copy of Windows 10 Home. During the install process, I was forced to create a PIN knowing that post-install I'd be able to use netplwiz to untick the box 'Users must enter a username and password to use this computer' to bypass the login screen going forward. Imagine my surprise when I discovered the option was missing, even though the netplwiz hidden Control Panel was otherwise identical to older Windows installations.

Where has it gone?

Ivars Akmenkalns



Memtest86 doesn't beat around the bush if it detects corrupt RAM.

APC Responds: Believe it or not, the option's absence is by design. Later versions of Windows 10 introduced Windows Hello, which offers a range of password-less sign-in options, including PIN, plus facial and fingerprint recognition. When you choose one of these features during the install process, Windows flicks the 'Require Windows Hello sign-in for Microsoft accounts' switch to On, which results in the option being removed.

The good news is that you can restore the option without disabling Windows Hello. Simply navigate to 'Settings > Accounts > Sign-in options' and flick the switch to off. When you next open netplwiz, the option should be available again.

If it's still missing, open Registry Editor and navigate to HKEY_LOCAL_MACHINE\SOFTWARE\Microsoft\Windows NT\CurrentVersion\PasswordLess\Device, then change the DevicePassword LessBuildVersion value to 0. Close Registry Editor and reboot.

Boot Camp upgrades

What options do the millions of Intel Mac users using Boot Camp to run Windows 10 have for upgrading to Windows 11?

Morris Pomey

APC Responds: The answer is, sadly, to look elsewhere. With its switch to M1 chips, Apple has phased out support for Boot Camp entirely as M1 Macs can only run an ARM build of Windows 11. Currently, this is still in preview, so not officially supported. The problem with older Intel-based Macs is that while later models ship

On receipt of the results, Corsair accepted the fault and authorised a return under guarantee of not just the failed DIMM but its matched pair. This ensures the replacements will be similarly matched.

with processors with TPM 2.0, the Mac motherboard doesn't support it. With Windows 10 supported until 2025, and Apple moving away from Intel chips, it looks like official support for running Windows on the Mac is coming to an end.

Prior to its official release, websites such as Apple Insider (<https://appleinsider.com/articles/21/06/25/intel-macs-cant-run-windows-11-without-this-workaround>) revealed ways of hacking the Windows 10 ISO installer to bypass the TPM 2.0 check and make it possible to install Windows 11 through Boot Camp. But there's no guarantee the workaround will continue to work.

If you're looking to run Windows 11 on an Intel-based Mac to run specific apps, then the most realistic approach is to invest in Parallels Desktop (\$109.95 standalone, \$137.45 annual Pro subscription, see www.parallels.com/au). This virtualisation software creates a 'virtual' TPM chip to meet the Windows 11 TPM 2.0 requirement. Performance isn't as fast as a native install, but it can be seamlessly integrated into your Mac environment. And when Microsoft releases the Windows 11 ARM build, it will work on M1 Macs too.

Drive storage query

It's time to replace the hard disk I use for extra backup. Due to over-

provisioning, I have two choices. Should I use the WD Black dated 2013 or the WD Blue dated 2020? Both are still in their original packaging and have the same capacity.

Pete Reque

APC Responds: We would not recommend storing a hard drive for eight years unused. Hard drives have a finite shelf life, depending on how they're stored and how often the data is accessed on them. Once a drive is in use, it's considered good practice to power it up at least once every five years to make sure its moving parts are in working order, and that the data on the drive isn't subject to magnetic field decay (the field is refreshed by reading and writing data to the drive).

The longer a drive is left unused or unopened, the greater the risk it won't work. That said, there are plenty of reports of people firing up PCs that have lain unused for ten years or more with no apparent ill-effects. Perhaps given your over-provisioning you could use the opportunity to use both drives: the newer one to replace your extra backup, and then test the older drive by using it for a few months as a fail-safe backup for the newer drive. If you're able to verify that it's still working after 3-6 months, you can then decide whether you can trust it on its own merits. ■

Security and the Internet of Things

Ian Evenden on how to lock-down any fishy behaviour from IoT devices.

There's a story that goes around cybersecurity events about a casino, somewhere in North America. It had a fish tank, and in that watery fish home was a thermometer. For reasons best known to the casino management, the thermometer was an IoT (internet of things) device and reported the tank's temperature via Wi-Fi. However, it wasn't particularly secure, and so hackers used it to gain a foothold in the gambling establishment's network, eventually escaping with a database containing the details of high-rolling customers. We hope the aquarium housed a marine environment, as it would make comparing the heist to the Oceans 11 movies easier.

That might sound pretty amusing when it happens to wealthy people with more money than sense, but a general lack of security in IoT devices is far less funny when it allows hackers to cuss at you through an insecure IP camera, as happened to one Dutch woman recently.

The fact is that many IoT devices are insecure from the moment you install them on your home network and allow them unfettered access to both it and the wider internet. Basic security issues, such as generic admin passwords and having remote access enabled by default, are relatively easy to fix, but there are also things you can do on your router to help

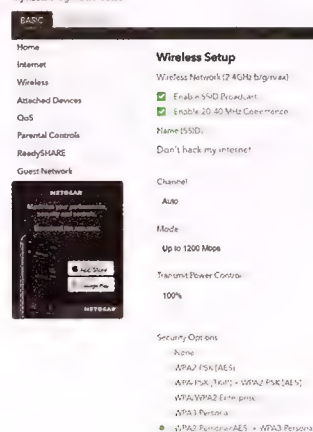
increase security, and prevent yourself from being 'fishtanked'.

Network security

There are plenty of steps you can take around your home network to reduce the likelihood of anyone making ingress from outside. The first is changing the name of your SSID to something that doesn't identify the manufacturer of your router. Remember that your chosen name will be broadcast into neighbors' houses, so hilarious names such as 'FBI Surveillance Van' or 'Number 42 We Hate Your Music' should definitely not be on the list if you value your neighborhood relationships. Try not to put any identifying information in the name, so not 'This Is The Goldbergs' Netgear Router' [Image A].

If you can live with a hidden SSID, then all the better, as your wireless network won't be nearly so obvious to someone with a laptop full of intrusion tools and a nose for mischief. Not everybody is prepared to live with the inconvenience, however, so the next thing to check is that you're using the best encryption protocol your router can manage. New devices must support WPA3 to get their Wi-Fi certification, but WPA2, with its mandatory AES encryption, is still a valid option. If you're using WPA, or even WEP, and are concerned about security, then getting a new router should be moved to the top of your to-do list.

My Router: NightHawk RAX80



YOU'LL NEED
PC, router(s),
home network,
IoT device(s)
Internet connection
Wi-Fi

Likewise, if you have an older device that can't access a WPA2 network, it's better to upgrade it than to compromise security.

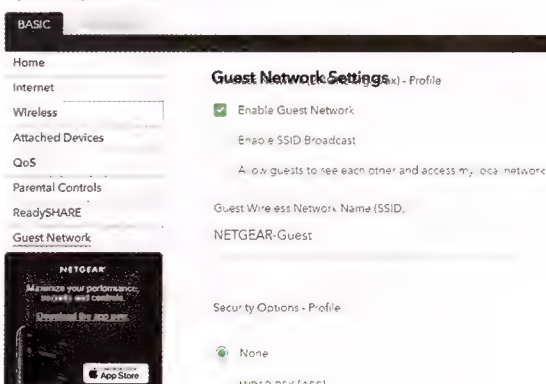
Separate your bands

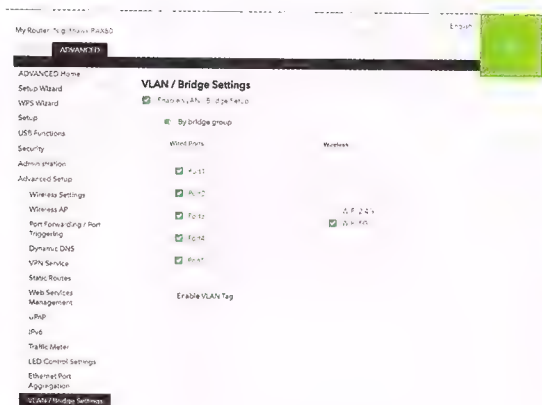
Most IoT devices connect at 2.4GHz, so you can move devices to the 5GHz band, if your router supports it, with no security implications. The 2.4GHz network has a better range but lower speed so can potentially pick up security cameras and Wi-Fi lights further away without needing a booster. This leaves the faster 5GHz network uncluttered for your phone, tablet, and PC. You get a faster and more stable connection through the Ethernet, so fixed devices, such as smart TVs, desktop PCs, NAS boxes, and media servers, can be wired in to take pressure off your Wi-Fi bands.

Guest network

Many routers support an additional virtual 'guest' network that is cut off from the primary one you use. It's not meant as a security measure, but something you can switch on when family comes to visit to save giving them your password, or if you're running a shop and want to offer customers internet access. However, because of its isolation from the rest of the network, it does have security

My Router: NightHawk RAX80





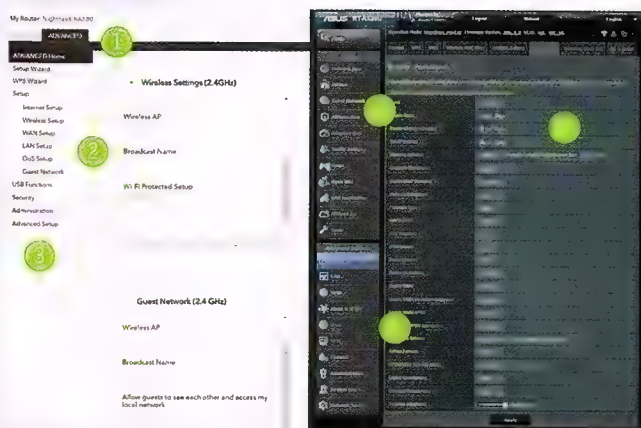
benefits – as long as that isolation is turned on. For some routers, it's on by default, on others you need to check a box. Some go further and isolate devices on the guest network from each other.

This is fine but cuts both ways. If you've isolated a device so it can't hop onto your main network, it means you can't get to it from there either. Luckily, most apps such as Alexa, Ring, and Logitech don't access your device directly across the network, but both the app and the device talk to the same server out in a data center somewhere. If you need to connect directly to the IP address of your device that's within the internal pool doled out by the router's DHCP server, then you're out of luck and will need to either reduce security or attach it to the main 2.4GHz network.

Our consumer Netgear AX router has little in the way of options and displays the Guest network page badly too [Image B]. We can set up a guest network on either the 2.4GHz or 5GHz bands, show or hide the SSID, and opt to add security, or not. Most importantly, there's a checkbox to prevent guest devices from seeing one another or the broader network. For IoT devices, this box should be checked. Note that Google routers don't offer even this level of security, allowing Guest devices to mingle with others.

Guest networks and Pi-Holes

If you're using a Pi-Hole to block ads then you need to allow these Guest devices to access the Pi-Hole, as it's acting as the network's DNS server and therefore the gateway to the wider internet. This comes down to your router firmware. You need to add the IP address of the Pi-Hole, which should be fixed.



ROUTIN' TOOTIN'

1 Advanced

This is where all the interesting tools are, though you can find security options in Basic too.

2 Guest Network

Both our Netgear and Asus (running Merlin firmware) routers make it easy to find Guest Network options.

3 Even more advanced

This is the home of the VLAN settings, which you should read up on further before tackling.

4 Asus General Settings

The Guest Network is high up on Asus's list, and it offers three to Netgear's one.

5 Wireless settings

Here, you'll find security, filtering, a block list, and advanced Wi-Fi settings, all in one place.

6 AP Isolated

This is a useful setting that can cut off one access point from the rest of the network.

This isn't an option anywhere in the settings of our Netgear router, and the same is true of a few other brands, including Apple and TP-Link. The only options seem to be hitting the button to allow Guest devices to see one another and the wider network, which defeats the entire point of doing this, or finding some custom router firmware that allows it, and doesn't open a dozen other security holes along the way.

VLAN

A Virtual LAN is like a beefed-up Guest Network. Routersecurity.org compares a VLAN to a fish tank. If you have two tanks, the

fish in one can't interact with the fish in the other. Put a curtain (or VLAN) between the tanks and they can't even see each other. Misconfiguring a VLAN can mean loss of internet connectivity, many router reboots, and general annoyance to everyone on the network, so go carefully. On our Netgear router, it's the last option in Advanced > Advanced Setup. Put your Ethernet ports and 5GHz Wi-Fi network in one VLAN, and the 2.4GHz network in another. Both can access the internet, but while devices on the 5GHz Wi-Fi and Ethernet can talk to each other, devices on the 2.4GHz wireless can't interact [Image C]. ■

ADD A SECOND ROUTER

Putting an old or unused router into your network to gain extra Wi-Fi networks if your main unit doesn't offer more than two is a good way to extend your network, but it's worth making sure that the secondary device isn't too old, as it may then become a security risk in its own right.

To do this, you'll need to put the secondary router into access point mode, which again is something that varies by manufacturer. On our Netgear router, we found it under Advanced > Advanced Setup > Wireless AP, but other models may vary. AP mode switches off the router's modem functions and slaves it to the DHCP service running on your main unit.

It continues to look after the wireless networks it deploys – typically one 2.4GHz and one 5GHz, though you don't have to use both – and routes all traffic through the main router onto the wider network or internet. There are still no options on the stock Netgear firmware to isolate a secondary router from the rest of the network, but you can use a VLAN to separate it off.



APPLE MAC

Use Tab Groups in Safari

The best way to run Linux or Windows on an M1 Mac for the present.

IT WILL TAKE
10 minutes

YOU WILL LEARN
How to add, rename and manage tab groups in Safari

YOU'LL NEED
Safari 15 or later, macOS Big Sur or Monterey

If you're anything like us, you probably have a ton of tabs open in Safari, all completely disorganised and disjointed. Every time a new project comes to mind, more tabs get opened, adding to the ever-growing mess. There is a better way.

With the arrival of Safari 15 for macOS Big Sur and Monterey, you can now organise your tabs into

Tab Groups – and even sync those Tab Groups across your other devices, as long as you're logged in with the same Apple ID.

You can easily create as many Tab Groups as you wish, making it easy to separate your most commonly used work and home tabs, or create Tab Groups for other projects.

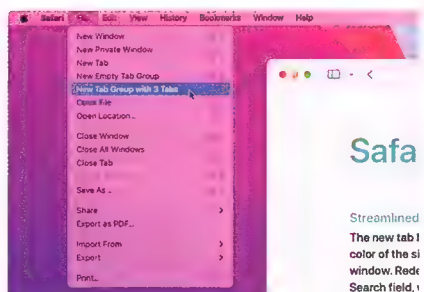
You can also easily edit,

rename and reorder your Tab Groups as well as preview their contents. And in macOS Monterey, you can easily share them with other apps such as Mail and Notes too.

In this tutorial, you'll discover how to do all of that and much more besides. So let's get started.

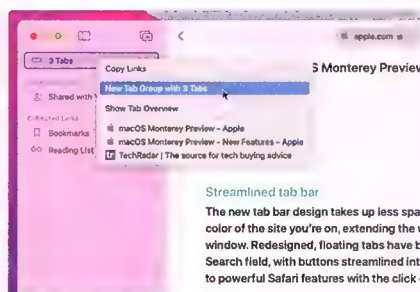
Alex Blake

HOW TO Manage Tab Groups in Safari

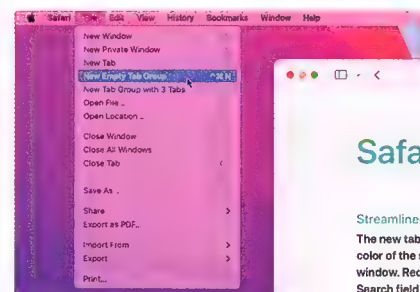


Safa

Streamlined
The new tab bar color of the sidebar, Red Search field,



Streamlined tab bar
The new tab bar design takes up less space of the site you're on, extending the search field, with buttons streamlined into powerful Safari features with the click.



Safa

Streamlined
The new tab bar color of the sidebar, Red Search field,

01 Create a new Tab Group

If you have several tabs open, you can create a new Tab Group by clicking File > 'New Tab Group with x Tabs' (where 'x' is the number of tabs you have open). All your existing tabs will be grouped together into a new, untitled Tab Group.

02 Use the sidebar

You can also create a new Tab Group from the sidebar menu. Click the sidebar button in the top-left corner of the Safari window, press up-command-L, or click View > Show Sidebar. With the sidebar open, click 'New Tab Group with x Tabs'.

03 Blank Tab Groups

To create a blank Tab Group, click File > New Empty Tab Group. This keeps any tabs you had open as well as the new Tab Group. To populate the blank Tab Group, open some new tabs or drag and drop tabs from another group.



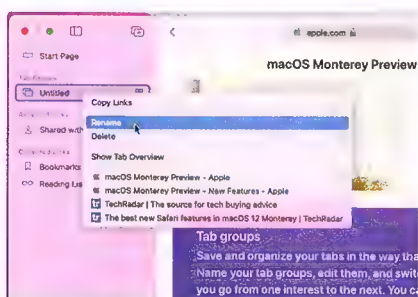
New features available with macOS Monterey.

macOS Monterey builds on the same powerful foundation as macOS Big Sur, while offering distinct experiences designed just for the capabilities of Mac.

Key Features and Enhancements

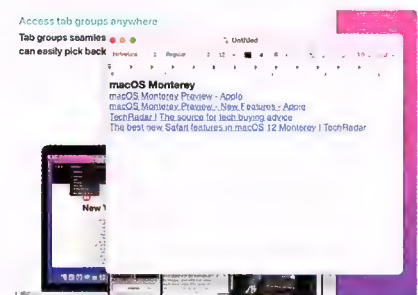
04 Add and remove tabs

Every time you open a new tab within a Tab Group, it is saved to the group automatically — there is no need to manually save the group. Likewise, you can delete a tab from the group by simply closing it and it will be removed.



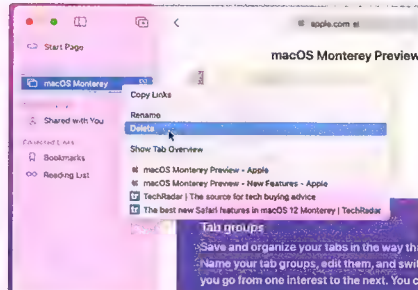
07 Rename and reorder

To rename a Tab Group, open the sidebar menu, control-click a Tab Group and click Rename or double-click the Tab Group name and type. Once done, press return. You can also change your groups' order by dragging and dropping them.



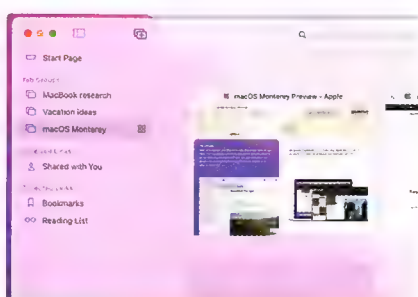
10 Copy and share tabs

To copy and paste your tabs into another app such as Notes or Mail, control-click a Tab Group and click Copy Links. At the bottom of the menu is a list of every tab contained inside the group. Click a tab and it will be opened in Safari.



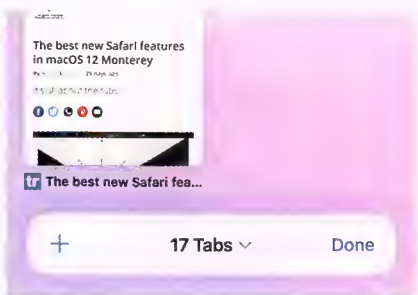
05 Delete a Tab Group

To delete a Tab Group, control-click it in the sidebar menu and click Delete. This will close every open tab in the group rather than ungroup them. To delete the group but keep its tabs open, move them from the current Tab Group to another.



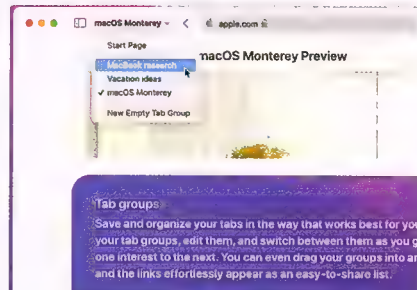
08 Tab Overview

If you forget which tabs are contained in a group, open the sidebar menu. To the right of the group's name is an icon that looks like four squares. Click it, or control-click the group and click Show Tab Overview to see a preview.



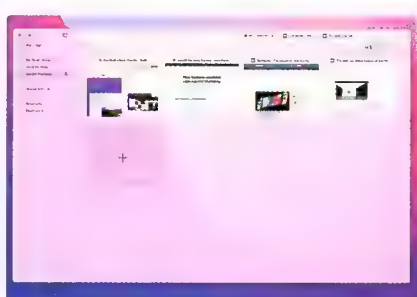
11 Sync to your devices

Any Tab Groups you have saved on your Mac will be synced to your other Apple devices. On an iPhone running iOS 15, for example, open Safari, tap the Tabs button, then tap 'x Tabs' (where 'x' is the number of open tabs) and choose a Tab.



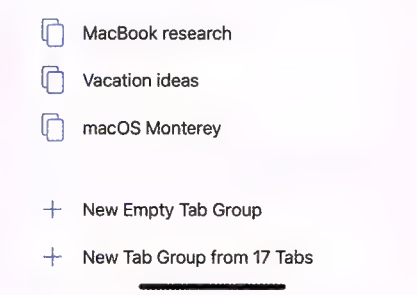
06 Change to a new group

With the sidebar closed, you will see the name of the current Tab Group in the top-left corner of the Safari window. Click it to move to a different Tab Group. Alternatively, open the sidebar menu and click a different Tab Group to switch to it.



09 Tab previews

From here, you can click any of the displayed tabs and Safari will switch to it. Each tab has a small 'X' button that lets you close the tab. After the last tab is a large square with a '+' inside it — click it to open a new tab inside this Tab Group.



12 And back to your Mac

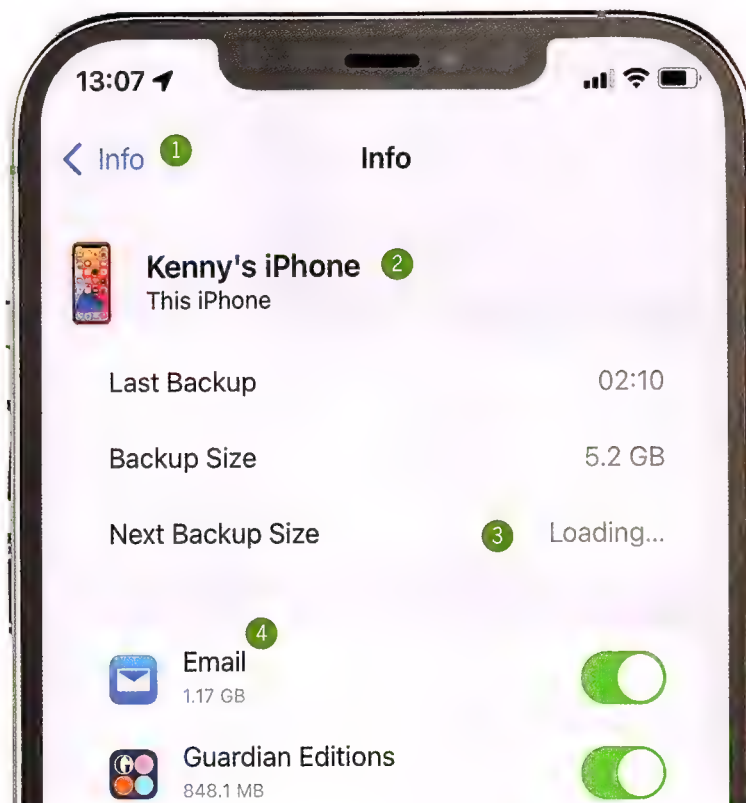
This works the other way, too. As long as your other devices are logged in with the same Apple ID, any tabs you add to a group on your iPhone or iPad will be added to the relevant Tab Group in macOS Monterey. ■

1
STORAGE OPTIONS
Options for controlling which apps back up to iCloud are found in Manage Storage.

2
ALL DEVICES
On any device, you can see the storage options for all the devices connected to your Apple ID.

3
BACKUP SIZE
This screen also tells you the next backup size, so you can switch off some items or buy more storage.

4
BACKUP LIST
You'll find all the apps you can back up to iCloud listed here, each with a toggle switch for inclusion.



APPLE iOS

Customise iPhone backups

Save space in iCloud by selecting what is backed up from your iPhone.

IT WILL TAKE
30 minutes

YOU WILL LEARN
How to customise backups of your iPhone to iCloud

YOU'LL NEED
iPhone, iCloud account

Once upon a time, backing up your iPhone meant physically connecting it to your Mac. That was soon followed by the ability to synchronise wirelessly with iTunes on your Mac. Now, you don't need to keep backups on your Mac at all (though it's something we advise you do from time to

time), thanks to iCloud.

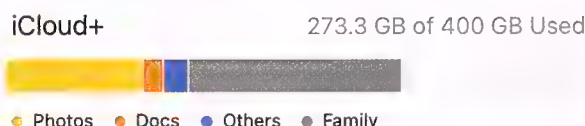
All you have to do is turn on iCloud backup and your iPhone will back itself up in the background to your iCloud account and you won't even notice it's doing it. Or at least, you won't notice until you see a larger dent in the available storage in your iCloud account,

especially if you don't pay for one of the iCloud+ storage tiers.

Fortunately, you can customise what data makes its way to iCloud when your iPhone backs up. Specifically, you can turn off data on an app-by-app basis. This does mean, however, that if you run into a problem and need to restore your iPhone from a backup, data for any apps you've chosen not to back up will be lost. It's also worth noting that the switch that controls the iCloud backup for each app is different from the one that turns off all iCloud features for the app. So if you use iCloud to synchronise between devices, you can still do that, even if you turn off iCloud backup for that app. Photos has its own system, iCloud Photos. To free up the space it uses, you will need to turn off iCloud Photos on all your devices. You then have up to 30 days to download everything.

We'll show you how to set up iCloud backup, how to customise it, and how to restore your iPhone from an iCloud backup.

Kenny Hemphill



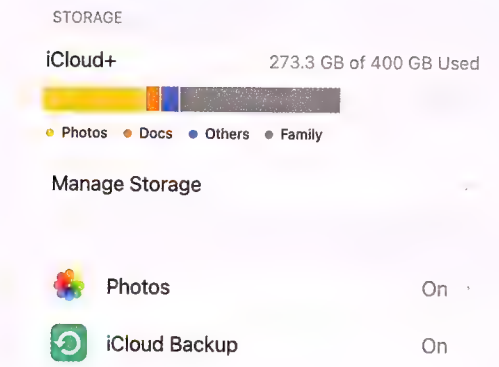
Family Usage 147.5 GB

Change Storage Plan 400 GB

 Photos 94.5 GB

Even large iCloud+ storage allowances can quickly fill up with backups, especially on family accounts.

HOW TO iCloud backups on your iPhone



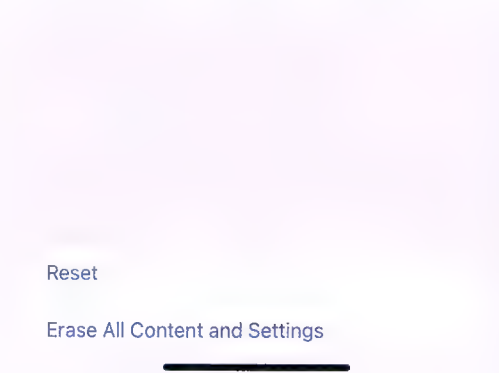
01 Turn on iCloud backup

Tap Settings, then tap your Apple ID. Choose iCloud, then iCloud Backup and toggle the switch to on. Alternatively, after tapping your Apple ID, tap the name of your device, then iCloud Backup and toggle the switch on.



03 Backup space

To see how much space backups are using in iCloud, go to Settings > Apple ID and tap Manage Storage. Tap Backups and you'll see the devices that have been backed up to iCloud. Tap one for more details.



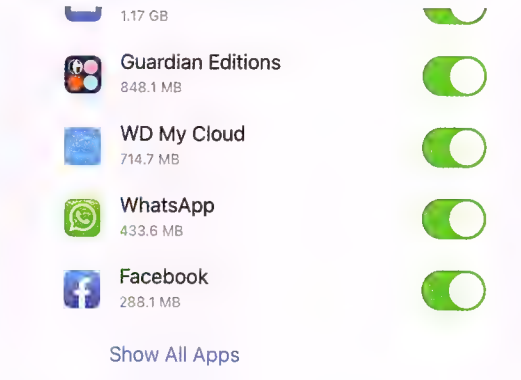
05 Erase and restore

Before you restore from an iCloud backup, you'll need to erase your device. Tap Settings, then General. Scroll down and tap Transfer or Reset iPhone then choose 'Erase All Content and Settings' to erase and reset your device.



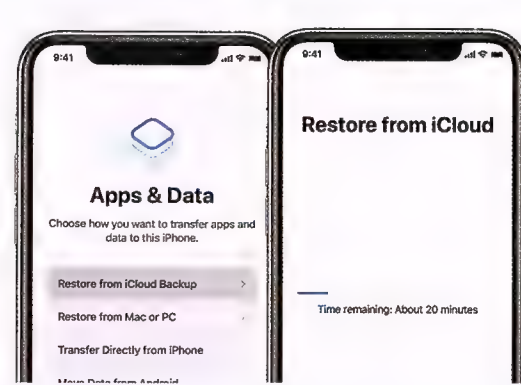
02 Back up immediately

In addition to turning on automatic backups, you can make ad-hoc backups. In Settings > Apple ID > iCloud > iCloud Backup, under the toggle switch, tap Back Up Now. This will initiate a new backup of your device.



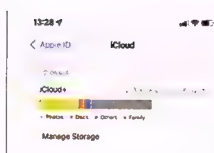
04 Manage backups

In Settings, tap your Apple ID. Tap iCloud, then Manage Storage. Tap Backups then tap your device. Wait until apps are displayed, then tap Show All Apps. Toggle the switch next to an app to turn off backups.



06 Restore from iCloud backup

When your device restarts, go through the setup process. At the Apps and Data screen, choose Restore from iCloud Backup. Enter your Apple ID and password, tap Agree and choose the backup you want to use.



JARGON BUSTER
iCloud+ is the new name for the premium tiers of iCloud that include storage, as well as services like Private Relay.



GENIUS TIP!
To save more space, set deleted emails to be removed after one day. Settings > Apple ID > iCloud > Mail > Advanced > Remove.



The Atari 800 looks like something from the set of *Blade Runner*, and it is a joy to behold. A chunky, industrial aesthetic that pleases.



LINUX

Going back to 8-bit with the Atari 800

Les Pounder goes back to a time before E.T. cartridges were buried in the desert and 48KB was considered lots of RAM.

The first exposure to an 8-bit Atari I had was the 65XE, owned by my mate Scott. Sitting down to play *Millipede*, we had a thoroughly good time. Atari's 8-bit range of home computers dominated the US market but in Australia, as with the UK, the home computer wars were mostly fought between Sinclair, Amstrad and Commodore.

Released in late 1979, the Atari 800 and other Atari 8-bit machines of the era were originally developed as a second generation of Atari's popular VCS consoles. But Atari president Ray Kassar wanted to challenge Apple, who had the most popular home computers at the time.

The Atari 800 was marketed as a

"timeless computer", driven by how well it could be expanded.

The Atari 800's MOS 6502 CPU ran at 1.79 MHz (NTSC) and 1.77 MHz (PAL) and had 16KB, later upgraded to 48KB of RAM. Later the 800XL came with 64KB of RAM. Of the 8-bit Atari's of this era, the 800 and 800XL were the premium models, featuring chunky, clunky keys that could withstand the hammering of an eight-year-old gamer. The beige plastic aesthetic screamed typewriter meets *Blade Runner*, which was a good thing. The 800 had two cartridge slots, one of which is often used for the bundled Atari BASIC cartridge (the 800XL had this built in).

QUICK TIP

The default emulator window size is tiny! Change this by using the `win_height` and `win_width` commands when starting the emulator. Just type the following for a 720P display:
atari800 -win-height 720 -win-width 1280

In order to emulate the 800 we chose *atari800*, available via the Ubuntu repositories. Installation is a breeze. Open a terminal and first update the repositories, before installing the emulator.

```
$ sudo apt update
```

```
$ sudo apt install atari800
```

To start the emulator, in a terminal type the following.

```
$ atari800
```

You will notice that the emulator starts in a self-test mode; this caught us out, but it is a useful tool nonetheless. Pressing F3 (the Select key on an Atari 800XL) switches between the tests. We chose the audio test, then pressed F4 (Start key) to run the test. We were presented with a simple audio test which played a tune similar to that played by Captain Picard in the *Star Trek The Next Generation* episode 'The Inner Light'. To stop the test and boot the Atari 800 normally, press F5.

To skip the self-test completely we can start the emulator with an argument:

```
$ atari800 -basic
```

The *atari800* emulator is full of rich features, but they are a little hidden. To access the menu press F1 and you will see a plethora of options. In the course of this feature the main sections we will use are Disk Management, Cartridge Management, System Settings and Emulator Configuration. Using the arrow keys, navigate down to System Settings and press Enter. Here we



The Numen demo is an excellent showcase for clever programming on low-spec hardware.

can change our Atari model, from the Atari 400 all the way to a 130XE. The best overall compatibility comes from the Atari 800XL. We can also change between a PAL and NTSC video system, not a big thing now, but NTSC machines run a little quicker than their European cousins. Emulator Settings, also found in the main menu, is where we can set our emulator to boot into the BASIC interpreter, run a tape on boot (press F4 and Shift-F5 to load) and also set our machine into Turbo mode. Turbo mode makes the BASIC interpreter a little twitchy so perhaps only use it if you are booting directly into a game.

Intro Atari BASIC

Atari BASIC, released in 1979 and created by Paul Laughton and Kathleen O'Brien, was a little different to other versions of BASIC in this era. It wasn't based upon Microsoft's BASIC and it had a few keywords that were specific to Atari BASIC. Originally distributed as an 8KB ROM cartridge, BASIC was soon added as a built-in option for the 600XL and 800XL. There were three releases of Atari BASIC, each fixing bugs and introducing new features.

Revision B was meant to fix all of the bugs in Revision A, including a pesky bug that added 16 bytes to a program every time it was saved and loaded into memory – not ideal when the max RAM was 48KB. All versions of BASIC were provided on cartridge, but some machines, notably the 800XL, XE and XEGS models had it built in.

To determine what version of BASIC we have is pretty simple. In the BASIC interpreter we can type this command to return a value:

```
PRINT PEEK(43234)
```

Revision A is 162, Revision B 96 and Revision C 234. Our emulator is running Revision C.

Okay, let's flex a little BASIC muscle. We've done this a few times on many different machines but we start as always with the ol' 10 PRINT project. Each line of BASIC code for a project will start with a number, 10, 20, 30 and so on. This tells the interpreter the sequence of code; it jumps from one line to the next in ascending order. But why do we do this? Quite simply if we make a mistake and miss out a line of code we can insert another line of CODE without messing up the original code. Let's do the 10 PRINT project to illustrate this.



In the 1980s and '90s, Archer Maclean was a god for home computer fans. *International Karate* was a particular favourite for the humble C64.

10 PRINT "HELLO WORLD"

```
20 GOTO 10
```

If we RUN this code it will print HELLO WORLD over and over again. Press F7 on the keyboard to break the running code. But what if we want to add another line? We can insert a new line between 10 and 20. Logically this would be 11, giving us many more options to expand or correct the code. But we are going to use 15 as this is just a simple test.

```
10 PRINT "HELLO WORLD"
```

```
15 PRINT "LFX ROOLZ"
```

```
20 GOTO 10
```

Now RUN this new code and you will see alternating lines of HELLO WORLD and LFX ROOLZ on the screen. Press F7 to stop the code.

Making music

As always, we take our BASIC projects a little further and in the past we have made apps to calculate maths problems, controlled turtles, and drawn psychedelic patterns in pixels. This time we shall create a simple progression of three notes.

Start the Atari 800 emulator in BASIC mode.

```
$ atari800 -basic
```

The first line is a variable called DURATION and as you may have guessed it will control the length at which a note is played. We've chosen 45 'clock ticks', about half a second.

```
10 DURATION = 45
```

Line 20 sees the first note to be played. Atari BASIC has no means

ONLINE EMULATION

If you just want to play games and not have to worry about setting up an emulator, you're in luck as there are many just like us. The emulator jsA8E at tinyurl.com/APC502atari, from way back in 2014, runs the Atari 800 in your browser using JavaScript. It seems that online emulators written in JavaScript for retro computers is a big thing. In the course of this series we have encountered online emulators for all systems, even the 486 PC! This emulator takes you straight into a game, and we can recommend *Donkey Kong*; it feels arcade-perfect and plays like a dream.

We found a great resource for online emulators at tinyurl.com/APC502java. Here we found many different emulators with one thing in common, they are all written in JavaScript. The jsA8E emulator is there along with Javatari.js for the Atari 2600, and even a great Atari ST emulator in the form of EstyJS. The power of JavaScript as both a general-purpose language for the web and a serious emulation development platform is evident by the sheer number of emulators on offer – preserving the history of computing from the comfort of our browser window.

to control the duration for which a note is played so we shall hack a **FOR** loop to play it for the duration of 45 ticks. In the **FOR** loop we use the **SOUND** command to control voice 0, with a note of 121, tone of 10 and loudness of 15. Feel free to tinker with the note – musicians amongst us will soon work out the tones to notes.

```
20 FOR I = 1 TO DURATION : SOUND 0, 121, 10, 15 : NEXT I
```

Line 30, and here we add a short pause before playing the next note. We have to introduce a pause in this manner because Atari BASIC, like other versions of BASIC, does not have a **SLEEP/PAUSE/WAIT** keyword.

```
30 FOR I = 1 TO 10 : NEXT I
```

The next sound plays a slightly different note which shows a progression. Again we are controlling voice 0 and the loudness remains the same, 15.

```
40 FOR I = 1 TO DURATION : SOUND 0, 96, 10, 15 : NEXT I
```

Line 50 is another pause.

```
50 FOR I = 1 TO 10 : NEXT I
```

Line 60 sees the final note in the progression.

```
60 FOR I = 1 TO DURATION : SOUND 0, 81, 10, 15 : NEXT I
```

A final pause.

```
70 FOR I = 1 TO 10 : NEXT I
```

Lastly we turn off any audio.

```
80 SOUND 0, 0, 0, 0
```

When ready type **RUN** and press Enter to run the code. You should hear a short three-note progression. To run the three-note progression continuously we need to put it into a loop and for that we add line 90, which instructs the code to go back to line 20 and play the first note.

```
90 GOTO 10
```

Type **RUN** and press Enter to run. The three notes will play indefinitely, but you will soon grow weary of them. To stop the running code press F7 and this will cause the currently playing note to hang, to quickly stop it type this and press Enter.

```
SOUND 0,0,0,0
```

Playing games

The Atari 800 had three ways to load games. First there are the cartridge ports, we can connect a cassette tape drive, or we can use

QUICK TIP

Using the System Settings menu we can easily upgrade our humble Atari 800 with more RAM. From the main menu we can add additional disk drives, cartridges and tapes. Press F1 to access the main menu and then choose the peripherals that you need.

floppy disks. Australian users will be familiar with cassettes and cartridges. Tapes were the cheapest and most prevalent way to sell and, ahem, 'redistribute' games. In our tests we found that tape images often failed to load, and we had greater success with disk images.

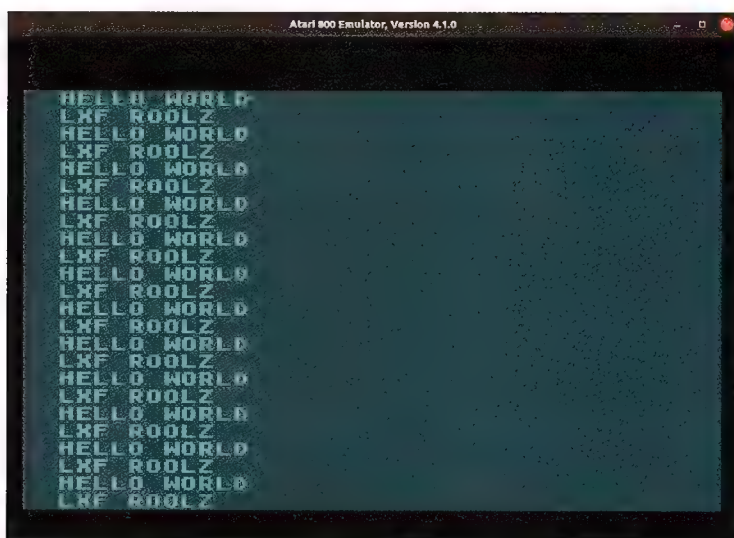
To load a disk image, you will need your .ATR disk image in a convenient location. In the emulator open the main menu, F1. Press the down key until you reach Disk Management and press Enter. There are eight possible drives; most games come on one disk so press Enter on D1. Navigate to your chosen game – note that the emulator will default to the directory from where you opened the emulator. Press Enter to select the disk then press **ESCAPE** to return to the **READY** screen.

Press F2-Shift-F5 to cold-restart the Atari 800 with your game in the drive and it will auto-boot. We tested this with Archer Maclean's awesome *International Karate*, and we may have played it for an hour, just to make sure it worked.

Loading a game from cartridge follows a similar process. First we press F1 to load the menu, then navigate to Cartridge Management. Select Cartridge: None and press Enter. Select your cartridge image and press Enter. You will then be asked what type of cartridge it is, and here is where a little trial and error is required. You will see repeated errors until you select the correct cartridge type. For some games you will have to go into the System Settings menu and change your machine to match the supported systems for that cartridge. The best gaming experience comes from using disks – they are fast and work well.

The demo scene

You might expect that the Atari 800 would be too pitiful of a machine for a demo scene. How wrong you'd be! The Atari 800 may not be the most powerful machine, but the demo scene provides plenty of examples illustrating what clever coding can achieve with limited hardware. The pinnacle of the Atari 800 demo scene is Taquart (TQA) Numen. The demo requires 320KB or more of RAM. To enable this we pressed F1, navigated to System Settings, pressed Enter and then set the RAM size to 320KB (Rambo). The demo starts with a walk through a wooded area, as we approach two guards. Then we enter a new world, a *Doom*-type

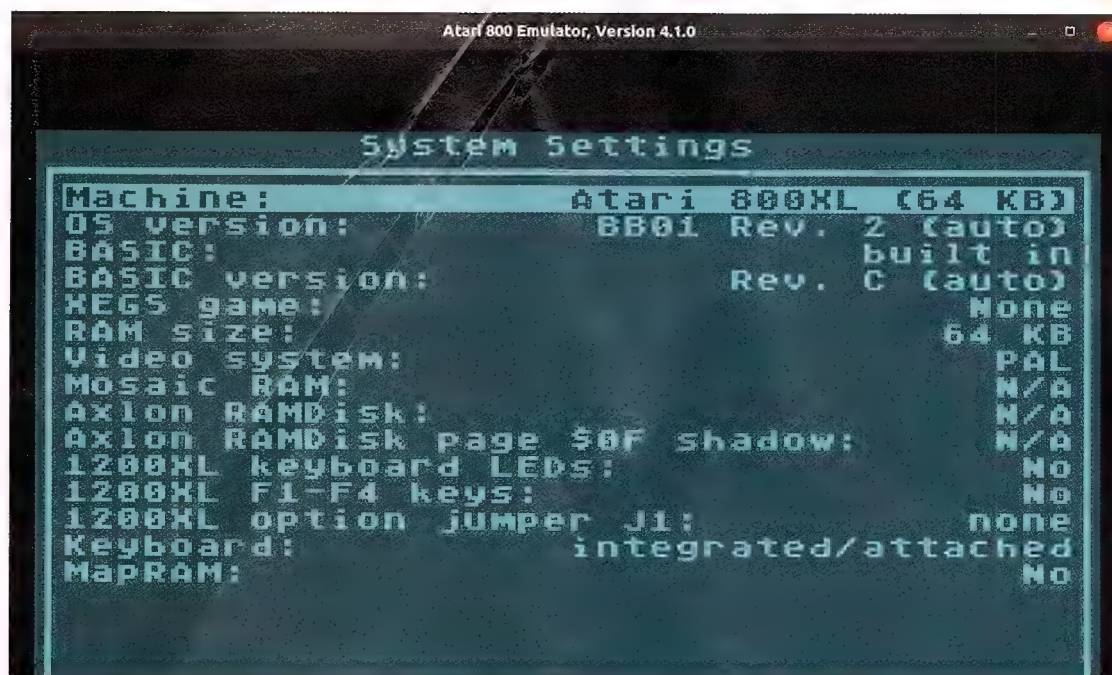


No 8-bit machine would be complete without some sort of BASIC, and Atari BASIC is a little different to most, but we enjoyed our time with it.

RESOURCES USED IN THE FEATURE

When writing features we go to multiple sources and for the Atari 800 we went to the Atari BASIC wikipedia page https://en.wikipedia.org/wiki/Atari_BASIC to get a handle on this version of BASIC. From here we learnt about Atari BASIC's limitations with strings, requiring a string to be created with a maximum length (a Dimension) so that we don't use too much memory. Remember that some Atari 8-bit machines have just 16KB, so every character counts. The keyword list was especially helpful in researching what projects we could create, and finding the **SOUND** keyword sent us off into a world of noise.

The Atari 800 emulator itself has an excellent help page at tinyurl.com/APC502A800 which enables you to learn how to select options in the self-test tool, reboot and make the Atari 800 ready to run a tape/disk/cartridge on boot. It also enables you to up the resolution of the application, so that screenshots were possible. Knowing the correct switches to add when calling the emulator also helps a lot.



Fancy a new Atari but can't cover the cost? Try before you buy! System settings enables us to swap 8-bit Ataris at will.

maze. The demo then proceeds to wow us with all the demo scene tricks in the book, accompanied by a thumping 8-bit tune. 3D worlds, lighting effects, line art and fluid animation all from one 5.25-inch floppy disk and 320KB of RAM. Take a look for yourself at www.youtube.com/watch?v=J2Abi02Tlwk.

The Atari 800 in 2021

Just like other '80s computers, the Atari 8-bit range has seen interest from nostalgic gamers and coders eager to reminisce about long tape-loading times (we jest – as any C64 or Spectrum user can attest, we waited a long time for games!).

For around \$90 we have SIO2SD from <https://lotharek.pl>. This device emulates an 5.25-inch floppy drive and we can load an SD card with hundreds of games and applications. We can also save and load BASIC applications directly from the card, preserving our own projects for use with emulators and other models of Atari.

If you would like to take advantage of the Atari 800's built-in cartridge ports then the ATARIMAX flashcart (www.atarimax.com) and software enable you to create your own cartridge-based compilations, ready to go in seconds.

The Rolls-Royce of modern loaders is the SDrive-MAX, an Arduino-powered floppy drive and cassette emulator that enables the user to load and save data with relative ease. The SDrive came onto

QUICK TIP

if your BASIC code won't stop running, fear not! Stop your code dead by pressing F7. If you are making music, remember that you will also need to turn off the audio using SOUND 0,0,0,0 otherwise you will get complaints from the neighbours.

the scene in 2008 and it has been updated over the years to the MAX variant. For around \$68 the SDrive-MAX looks to be the best option for overall ease of use and compatibility at a reasonable price.

But what about original Atari hardware? Well, looking around online auctions we can see that Atari 800XL are quite sought-after machines. We saw one for sale at \$320, and others with bids approaching \$150 with over a week left. External drives were going for \$125, cassette and floppy games hitting between \$10 and \$20.

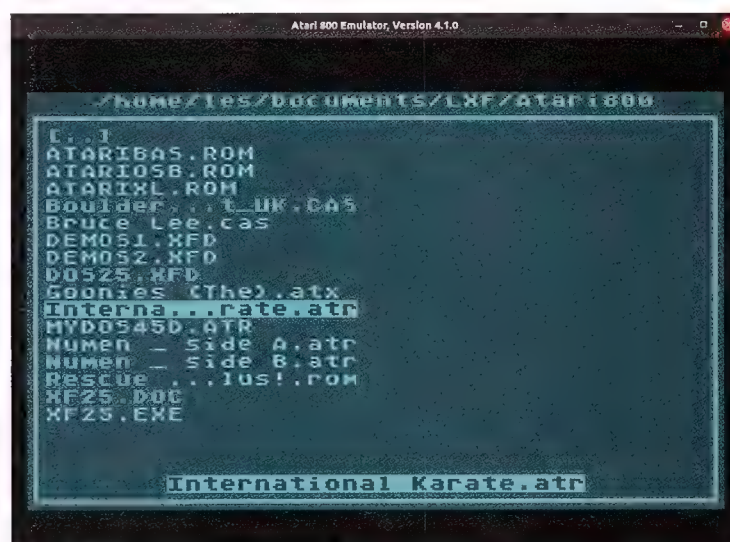
Before you go off to spend your money, remember this. Old hardware needs careful attention; your dream machine may have

been in an attic for 20 years, or kept mint in a box in a collection. Check with the seller before you buy, and make a note of any issues for your YouTube research. A good reference is Adrian's Digital Basement. Adrian has repaired and spoken about 8-bit Ataris and would be a good resource to learn from.

The Atari 800 legacy

The industrial/sci-fi design of the Atari 800 made it a joy to look at. The games and community around it have blossomed and while it may not have had the success of the Commodore, Sinclair and Amstrad, it has something more important: the love of a community who still to this day supports and nurtures this ancient but humble home computer. ■

Swapping disks is easy: just open the menu, pick a disk and the emulator mounts it ready for use. All we need to do is reboot the Atari and our game loads.



RASPBERRY PI

Building a better file server with the Pi

Christian Cawley shows you how to get the most out of your Raspberry Pi-powered Nextcloud server.

Running your own cloud storage server saves money, allows you to expand storage as necessary, and can be done with a device as small as a Raspberry Pi. Our previous guide to setting up a Nextcloud server on the Raspberry Pi (APC501) covered everything you need to know about installing and setting up NextCloudPi and the Nextcloud Ubuntu Appliance, as well as the manual installation of Nextcloud on Raspberry Pi OS.

But with the software installed and connected to your network, the job is only half-done. You still need to configure it for your specific use-case, enable external storage to reduce wear and tear on the Pi's SD card, and make the Nextcloud server accessible from beyond your home network.

The most straightforward way to set up external access to Nextcloud and to add external storage is to do it with the NextCloudPi installation.

External storage

The Raspberry Pi 3 and 4 boot from the SD card. While this can be changed in favour of a more reliable USB device, SD is the default option.

This has obvious advantages, from speed and convenience to simplicity. However, there is a key disadvantage, which is the longevity of the card: regular reading and writing of data to the SD card will shorten its lifespan.

Throw into the mix the fact that your NextCloudPi storage installation is limited to the size of the microSD card in your Raspberry Pi and you have an obvious problem. It's just not big



enough to compete with Dropbox or OneDrive or Google Drive, and you're limited to the maximum supported capacity of 1TB.

Adding an external disk drive to Nextcloud requires only a device with USB connectivity (unless you're using a case with a SATA adapter). For faster data transfer, use USB 3.0+ devices, and for the optimum, rely on SSD or NVME/M.2 flash.

First, connect the USB device and then set up an SSH terminal to your Nextcloud and enter

```
sudo mkdir /media/USBstorage
```

In your computer's web browser visit the NextCloudPi web panel (using the 4443 port, so [https://\[IP ADDRESS\]:4443](https://[IP ADDRESS]:4443)) and start the wizard if it doesn't launch automatically by clicking the wand icon in the toolbar. Select USB Configuration, input Yes, then

Connect a USB drive or full-size external hard disk drive to your Raspberry Pi for storage with Nextcloud – USB 3.0 preferred!

Continue, and Format USB.

When this completes, select 'Move data to USB'. You now have a Raspberry Pi-powered Nextcloud server that can store as much data as you need without wearing out the microSD card.

Static access

Configuring Nextcloud to be accessed from devices beyond your network (such as your mobile device while shopping) is possible with a static IP address. But before setting this up for external access, it's smart to configure the Raspberry Pi with a static IP address for access within your network – and, more crucially, your router – first.

To confirm the Pi's IP address and how it was assigned, open a terminal or SSH connection and enter

```
ip r | grep default
```

If you see the letters `dhcp` the IP address is assigned dynamically by the router. Make a note of the IP address, then check the nameserver or DNS IP:

```
sudo nano /etc/resolv.conf
```

Make a note of the IP address listed here for the nameserver before proceeding. Setting a static IP address can be achieved by editing the `dhcpcd.conf` file in `nano`:

Configuring Nextcloud to be accessed from devices beyond your network (such as your mobile device while shopping) is possible with a static IP address. But before setting this up for external access, it's smart to configure the Raspberry Pi with a static IP address for access within your network – and, more crucially, your router – first.

`sudo nano /etc/dhcpd.conf`

Add the following lines to the end of the file, changing the capitalised text with the information you have to hand:

```
interface NETWORK
static ip_address=STATIC_IP/24
static routers=ROUTER_IP
static domain_name_servers=DNS_IP
```

Change **NETWORK** to **eth0** or **wlan0**, depending on the network type (Ethernet or Wi-Fi).

For **STATIC_IP** enter the IP address you wish to use for the Pi – it's smart to use the one already assigned to maintain connectivity.

For **ROUTER_IP**, use the gateway IP for the router on your network – this address is usually printed on the router.

Finally, set **DNS_IP** to the IP address you made a note of after checking the **resolv.conf** file.

Finish by rebooting with

```
sudo reboot
```

Confirm the changes with Ctrl-X, then Y and Enter, and reboot. You can check the static IP address has been applied using

```
ip r | grep default
```

If you can't get a static IP address from your ISP – and many of them don't provide one (see boxout) – your best option for accessing the Nextcloud from anywhere is with a dynamic DNS provider.

Access anywhere

Start by accessing your NextCloudPi web panel and enter the credentials you used during setup.

In the web panel, find Networking and select 'letsencrypt' from the menu. Add a working email address when prompted and click the wand icon to launch the setup wizard and select 'External access'. Answer Yes, then wait for setup to complete. When prompted for Port forwarding, choose 'I will do it manually'.

You'll need to forward ports 443 and 80 (for HTTPS and HTTP) to the Raspberry Pi, targeting the router-assigned IP address for the device or its hostname (**nextcloudpi**). How you do this will differ from router to router. Many routers offer an online help tool, but you can also refer to the device's documentation to find out how to use port forwarding.

In the next screen, sign up to FreeDNS when prompted, select Subdomains and choose a free domain and subdomain, then

Vodafone Wi-Fi Hub

1 users logged in Some Expert Mode settings in use Expert Mode



Overview

Internet

Wi-Fi

Sharing

Settings

Status & Support

Firewall

IPv4 Port Mapping

IPv4 Port Mapping

IPv4 Port mapping allows remote computers to connect to a specific device within your private network

IPv6 Settings

Static NAT/DMZ

Static Port Mapping

DNS & DDNS

Mobile Data (3G/4G)

Dynamic Port Mapping

Set up cloud storage that you can access across the internet by configuring port forwarding via static IP or dynamic DNS.

input your router's public IP address (check by searching Google for 'what is my IP') and Save.

Next, choose Dynamic DNS and copy the Direct URL for your subdomain into a text file. Remove everything before (and including) the ? so you're left with a long alphanumeric string. On the FreeDNS screen in NextCloudPi, complete the Domain field with the subdomain you chose, then paste the alphanumeric hash from the text file into the Update Hash field and click Finish to complete.

With your Nextcloud installation now fully online it should be accessible from the mobile app or any other device through your browser.

Note that by establishing a static IP you may need to create a new connection in whichever version of the Nextcloud app you're using.

Enhance with apps

With the Nextcloud server

accessible from anywhere, there are a few things you can do to take it to the next level. Almost all those things can be found in the apps list. These were mentioned in the previous tutorial but there are several that can really enhance your Raspberry Pi cloud server if you're planning on using it for a home file and media server.

In the Featured Apps list, you'll find a list of snaps that are listed by type. In the Multimedia tab you'll find apps for playing media. There is also an app called Automated Media Conversion which converts media files using FFmpeg based on rules that you set. It can also convert files as they're uploaded.

Antivirus and anti-ransomware apps can also be installed to protect your cloud data, along with integrations with mainstream cloud solutions.

This is useful for easily migrating your cloud storage across rather than downloading to a PC and then uploading to the Nextcloud server. ■

QUICK TIP

Multiple hard disk drives or SSDs can be connected to your Raspberry Pi Nextcloud and they can run as individual devices or in a RAID setup of your preference.

CAN YOU GET A STATIC IP?

Internally, a static IP is relatively easy to set up: simply instruct the device what its IP address is (see main article) and go from there.

Beyond your network, it's a lot trickier. Dynamic DNS tools are useful and have largely replaced the need for a static IP from your ISP – but what if that's the route you'd prefer to take? Dynamic DNS solutions can fail, after all, making a static IP address far more reliable. Relying on your router's external IP address is a risk, as you don't know how often your ISP will refresh it.

In the past, a static IP address could be expensive. These days, however, having a static IP address is more affordable. Some domestic ISPs will let you have a static IP address for a monthly fee, others with a one-off setup free. Others still will require you to switch to a business account, which comes with some shortcomings you might not be comfortable with.

The best way to find out whether you can get a static IP address and learn about any associated costs is to chat with your ISP. You might be pleasantly surprised at how little it can cost!

MicroPython: coding your own hardware

Put your PC coding skills to work on a smaller scale and make your own hardware. Darren Yates explains how Python's little brother is democratising the Internet of Things.

If there's one programming language that's really taken the world by storm in the last ten years, it's Python. Its winning combination of easy-to-learn syntax and mountains of installable packages has made it the choice for everything from teaching kids to code through to university research and machine-learning. But that same combo is also lowering the barrier to entry into a mind-blowing world of hardware development, thanks to a version of Python designed specifically for stand-alone CPUs called 'microcontrollers'. Say hello to 'MicroPython'.

How microcontrollers make the world tick

You won't see an issue of *APC* pass by without at least several billion references to CPUs, clock speeds, motherboards, RAM and the rest. But these CPUs in our PCs are actually somewhat limited – they can achieve a seemingly-infinite array of amazing tasks, but they can't do it alone. CPUs have no RAM, storage and can't connect to anything in the outside world without lots of supporting electronics – after all, that's why we're all eyeing off new motherboards, right?

Meanwhile, there's another class of CPU that comes with its own storage, RAM, input/output (I/O) ports and can run off a couple of AAA batteries. These 'microcontrollers' are the building

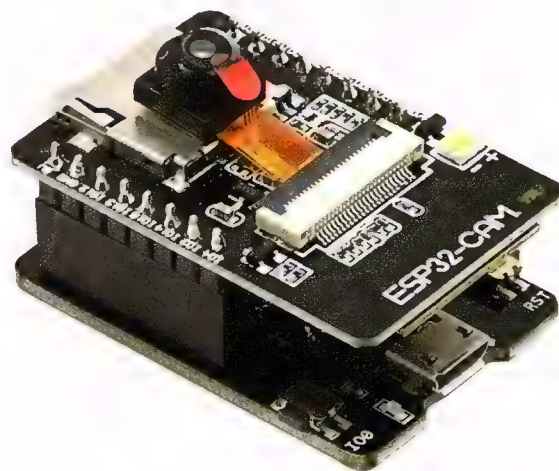
blocks for much of our modern society. The storage and RAM might be measured in quaint terms like 'kilobytes' (KB) and 'megabytes' (MB), the clock speed in 'MHz', but I'll say it right now – they do 'one thing' better than any Intel Core or AMD Ryzen CPU can.

Do one thing well

The trick is microcontrollers are also known as 'embedded' processors – you can code them to do many things, but they are typically embedded into a specific hardware application where they usually just have to do one thing, whatever that 'one thing' is. Increasingly, that 'one thing' involves environmental or weather sensing. But you'll find microcontrollers helping out inside your phone, handling tasks such as radio data transmission and other low-level functionality, they're even in your activity tracker.

About 15 years ago, Arduino hit the market bringing a simplified version of the C++ programming language to previous-generation 8-bit microcontrollers. In more recent times, microcontrollers have received 32-bit CPU processing, more on-board RAM and storage, sufficient to handle more user-friendly coding languages, such as Python.

Microcontrollers are also examples of what's known as 'bare-metal' coding. Unlike your PC, you don't need to run your software



You can grab an ESP32/OV2640 2MP camera bundle for under \$20 online.

code on a Windows, macOS or Linux operating system. Your code is stored in the microcontroller's flash storage and runs directly on its CPU. Among the many advantages this brings are that your code isn't bogged down by an OS, it runs fast even on seemingly-slow CPUs and it'll happily run on five-eighths of nothing in terms of electrical power.

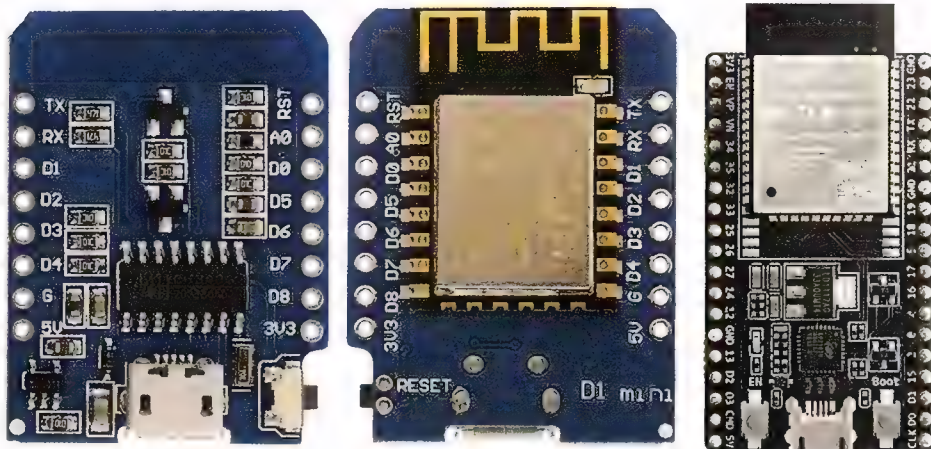
MicroPython is often described as a lean, efficient version of Python 3 designed to work in the constrained environment of microcontrollers. It's free and can be used to develop your own electronics projects using a range of microcontroller boards.

Interpreting the MicroPython differences

However, MicroPython is different to the C++ language that drives many microcontrollers in that it has to bundle the Python run-time engine with your code. When you write microcontroller code in C++, it is compiled and converted to machine-code the microcontroller natively understands. MicroPython, on the other hand, requires a small Python interpreter to be included that runs your code on the microcontroller CPU. This is why MicroPython has a minimum requirement of 16KB of RAM and 256KB of storage, whereas you can happily write C++ code for microcontrollers with 2KB of RAM and 32KB of storage (and often even less).

Below left: The original WeMos D1 Mini with 4MB of flash board sells for under \$5 online.

Below: The ESP32 development board has a dual-core 240MHz CPU for under \$10.





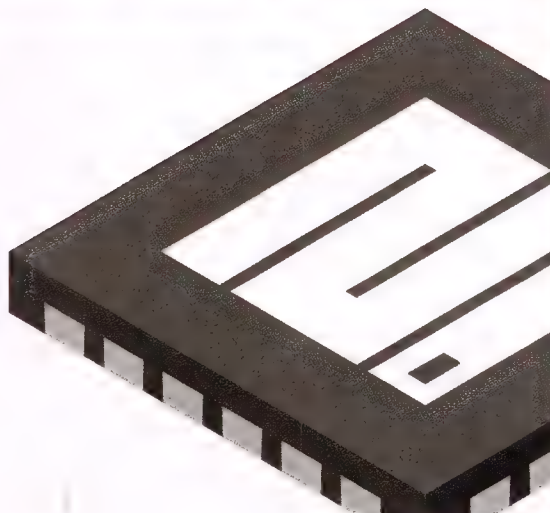
MicroPython

MicroPython is a lean and efficient implementation of the **Python 3** programming language that includes a small subset of the Python standard library and is optimised to run on microcontrollers and in constrained environments.

The MicroPython **pyboard** is a compact electronic circuit board that runs MicroPython on the bare metal, giving you a low-level Python operating system that can be used to control all kinds of electronic projects.

MicroPython is packed full of advanced features such as an interactive prompt, arbitrary precision integers, closures, list comprehension, generators, exception handling and more. Yet it is compact enough to fit and run within just 256k of code space and 16k of RAM.

MicroPython aims to be as compatible with normal Python as possible to allow you to transfer code with ease from the desktop to a microcontroller or embedded system.



Choosing a microcontroller

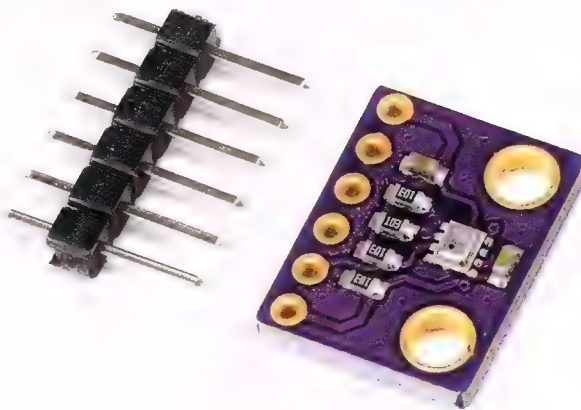
That means the traditional Arduino Uno, Nano or Mega boards cannot be used here. However, there are plenty of low-cost options available, the most notable examples being the BBC Micro:bit that we covered a few months ago, the Raspberry Pi Pico (RP2040) and Espressif Systems' ESP8266 and ESP32.

The ESP8266 features an 80/160MHz (turbo) 32-bit CPU with 112KB of RAM, split 32/80 instruction/user data and is usually optioned out with between 512KB and 4MB of flash storage, but make sure you choose an option with at least 1MB of storage. As a bonus, it also includes a full 802.11b/g/n Wi-Fi stack.

The ESP32 is the second-gen series, with either single- or dual-core 240MHz 32-bit CPU, 320KB of RAM and up to 16MB of flash storage (again you need minimum 1MB of flash for MicroPython to work well). Apart from the second CPU core on some models, the main difference here is that the ESP32 series includes both Wi-Fi and Bluetooth, so it's brilliant for wireless connectivity projects. You'll even find versions with a bundled two-megapixel (2MP) camera, selling for under \$20, good enough for facial recognition.

Get MicroPython

If you've got some experience with Python under your belt, MicroPython is a good way to get involved in the whole 'Internet of Things' game. You'll find the basic resources available over at www.micropython.org. However, if you're a newbie to coding, I'd recommend starting with a BBC Micro:bit V2 board – it's a great way to learn Python basics as they



Top: Never coded with MicroPython before? You'll find lots of docs and examples online.

Above: The Bosch BMP280 senses temperature, humidity and pressure, all for under \$2.

Take MicroPython for a spin online with a virtual PyBoard at www.micropython.org.

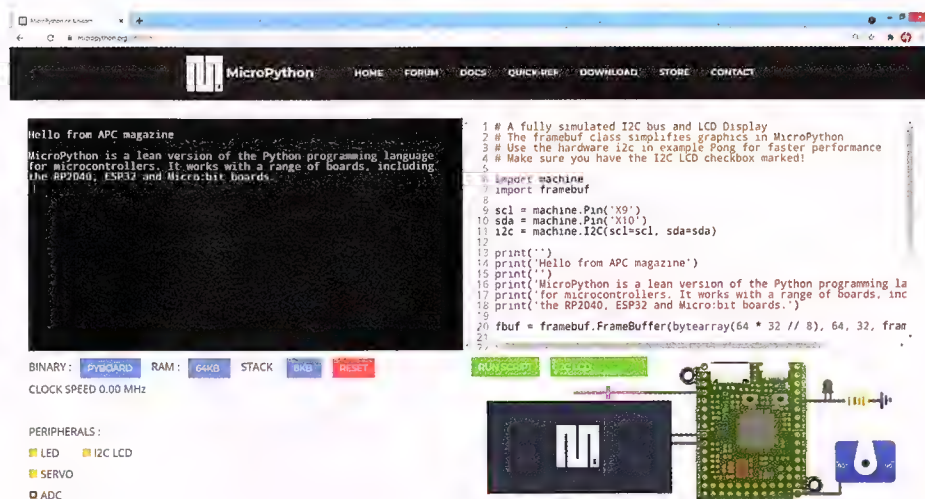
relate to microcontrollers without having to worry about all-things electronics as well. For the more adventurous, the RP2040 is a good choice with growing community support, but the ESP8266 and ESP32 series have been around for ages and are supported almost everywhere. You can code MicroPython on any PC - Windows, Linux, macOS, it doesn't matter – and you can even perform simplified machine-learning on these devices.

Have a go

One example project is to also grab yourself a Bosch BMP280 atmosphere (temp, humidity, pressure) sensor for under \$2 on Ebay and you're on your way to making your own wireless weather station (though you'll need some basic electronics and soldering skills at this point).

Nevertheless, I reckon skills in electronics and software development are as important as ever, particularly with the boom in Internet of Things and the rapid rise in digital farm technology. As the environment continues to go pear-shaped, 'food security' will be the buzz-phrase of the next decade. We'll need data to better understand agronomy systems and that data will come from a growing army of smart sensors – many, no doubt, coded with MicroPython.

So why not get involved? Coding is always much more fun when you've got a goal and there are few goals that beat building your own tech. ■



Despite their shortcomings (and mockery by *Red Dwarf*), these machines have the magic ingredient of classic home computers: a soul.

You'll need this
A copy of ZEsarUX
Available from GitHub.
[https://github.com/](https://github.com/chernandezba/zesarux/releases)
[chernandezba/zesarux/](https://github.com/chernandezba/zesarux/releases)
releases



MACHINE OF THE MONTH

Sinclair ZX80 & ZX81 (1980, 1981)

John Knight celebrates an all-time great in computer history.

For fans of microcomputers, the Sinclair ZX80 and its successor, the ZX81, were integral to establishing the home computing scene. The brainchild of British inventor, Sir Clive Sinclair, the ZX80 first brought affordable home computers to the masses in 1980.

As we began our research for this column, we heard the news that Sir Clive had passed away, aged 81. So it seems an even more appropriate time to pay tribute to a computing legend by covering the machines that kick-started Britain's coding revolution.

Development

Before the ZX80, Sinclair Research was already well established in the electronics world, pioneering devices such as cheap calculators and pocket

Specifications

CPU: Zilog or NEC Z80 clone @ 3.25MHz **RAM:** 1KB, 16KB max (ZX80), 64KB max (ZX81)
Graphics: 24 lines × 32 characters, or 64 × 48 pixels graphics mode (ZX81) **Sound:** None
Storage: Cassette **OS:** Sinclair BASIC **Released:** January 1980 / March 1981
Production: 1980 / 1981-1984 **Worldwide sales:** 100,000 / 1.5 million

televisions. It had developed a rudimentary computing kit under the former name of Science of Cambridge – 1977's MK14. But from 1980, the Sinclair name would forever be linked with affordable home microcomputers.

In the late 1970s, computers were far too expensive for most households. Obsessed with making sophisticated electronics available to all, Clive Sinclair envisaged a new microcomputer that, with clever simplification and cost-cutting, was affordable.

Chief design was entrusted to Jim Westwood, briefed with something that would cost under £100 while still making a profit.

Cost-cutting was applied. The base model came with 1KB of RAM and no sound output. Video output was black and white and the membrane keyboard was the worst in all Christendom.

It doesn't have a dedicated video chip but uses an ingenious workaround. By using static RAM instead of dynamic RAM, Westwood was able to exploit the Z80 processor's unused dynamic RAM interface to make the CPU do video processing.

The downside was that the ZX80 couldn't process video output and keyboard input simultaneously, resulting in an annoying screen flicker

with each keypress.

Despite its flaws, the ZX80 was a huge success, retailing for around \$140 or \$110 in kit form. However, customers soon discovered they couldn't do much with 1KB of RAM, making the 16K RAM expansion pack a must-have accessory.

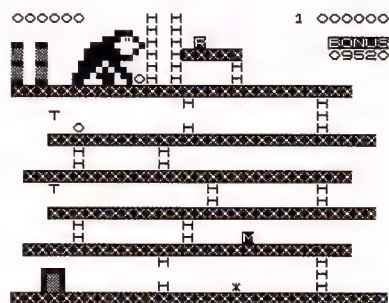
The following year, Sinclair upgraded the ZX80 design with the ZX81, addressing many flaws. The screen flicker was resolved by introducing "SLOW" mode, which used the Z80's interrupt mechanism to control when to output the TV signal. The ROM was upgraded to include floating-point computations, additional commands, and ZX Printer support.

The ZX81 used an Uncommitted Logic Array (ULA) chip from Ferranti, reducing the chip count from 21 in the ZX80 to just four. This allowed Sinclair to sell the ZX81 even cheaper. In March 1981, the ZX81 cost around \$100 assembled, or \$70 for a kit.

Gaming

ZX80 games aren't common, but as the ZX81 doesn't have proper graphics, its games were based on text block characters. They were often ambitious within these limitations.

The Gauntlet (1982) is a great arcade bomber, and *Mazogs* (1982) is an



Sinclair's machines are treasure troves for ASCII art fans. Paul Farrow's ZX80 *Kong* (2010) nicely re-imagines the classic *Donkey Kong* game via text characters.

intriguing maze explorer with cool aesthetics. *3D Monster Maze* (1981) and *3D Defender* (1981) push the limits of ASCII art with first-person 3D perspectives. Brazilian platformer *Em Busca Dos Tesouros* (1986) sports impressive animations and brutally difficult gameplay.

Both machines had dedicated masochists who squeezed whole games into 1KB for stock machines. *1K Space Intruders* (ZX80, 1981), *1K ZX Chess* (ZX81, 1982), and *Nohzdyye* (ZX81, 2019) are all examples of coding at its absolute leanest.

Clever coders eventually figured out ways of piecing together one-line slices of Sinclair's character set to emulate the look and feel of sprite graphics. Games like *Forty Niner* (1982) and *Rocket Man* (1984) achieved impressive results, though the geometry looked wonky.

Legacy

While the ZX80 had a strong showing with sales of over 100,000, they were dwarfed by the ZX81, which enjoyed sales of more than 1.5 million.

An enormous fan base developed and conventions were flooded with Sinclair users. Third-party vendors sold hardware add-ons, such as disk drives, improved cases, and better keyboards. Software houses sold cheap software on cassette, along with endless programming manuals.

Both computers spawned clone machines. The ZX80 had clones in Brazil and the US, while the ZX81 had clones in Brazil, Argentina, Hong Kong, and China.

In the US, third-party production was licensed to the Timex Corporation. Its first launch was the Timex Sinclair 1000, an NTSC-modified version of the ZX81 that shipped with 2KB of RAM.

Initial sales were strong but diminished after customers discovered

FINDING SOFTWARE?

While ZX81 software is plentiful, ZX80 software is difficult to find, though there are plenty of programming manuals. There are links on forums, such as sinclairzxworld.com, but a great source of ZX80 software is Paul Farrow, who runs the Sinclair ZX Resource Centre at www.fruitcake.plus.com. Paul has an impressive collection of materials for both the ZX80 and ZX81. ZX80 games include conversions of gaming classics such as Kong and Pacman, without screen flicker.

Paul is renowned for pushing the limits of Sinclair machines. His 2016 title, *Against the Elements*, pushes the ZX81 to near-Spectrum levels of performance, with color support via his Chroma SCART interface.

For other ZX81 sources, www.rwapsoftware.co.uk has received permission to host the software on display. Paul also asked us to link the archives of www.zx81stuff.org.uk, and Bob Smith's new games at bobs-stuff.itch.io.

the limitations of so little RAM.

Apparently, Timex hadn't debuted with RAM expanders, though this may be internet misinformation. Improved models followed, with better keyboards and more RAM, but American rivals soon price-matched Timex with stronger computers.

The reign of the Sinclair ZX81 ended with the arrival of the ZX Spectrum in April 1982. Users and developers were both quick to move to the new machine, which had both sound and colour. Games for the ZX81 dried up shortly afterward and the machine itself was discontinued in 1984.

Emulation

Numerous emulators are available, but our favorite is ZEsarUX. It is simple to use, doesn't require system ROMs, and emulates other machines, including Sinclair clones.

ZEsarUX supports Windows, Linux, and Mac OS, plus a host of lesser-known systems.

The URL for the emulator is <https://github.com/chernandezba/zesarux/releases>, but you could just google "github zesarux" instead.

On the right of the project's GitHub page, there is a link called "Releases".

Platform-specific binaries are provided in compressed files, and some Linux distributions may already have ZEsarUX in their repositories.

For Windows users, extract the ZIP file and open the destination folder. ZEsarUX doesn't come with an installer, so you will have to open the executable manually. Double-click `zesarux.exe` to start the program.

For Linux users, download and extract the binary tarball. Open a terminal in the new folder and enter the command:

```
$ ./zesarux
```

Usage

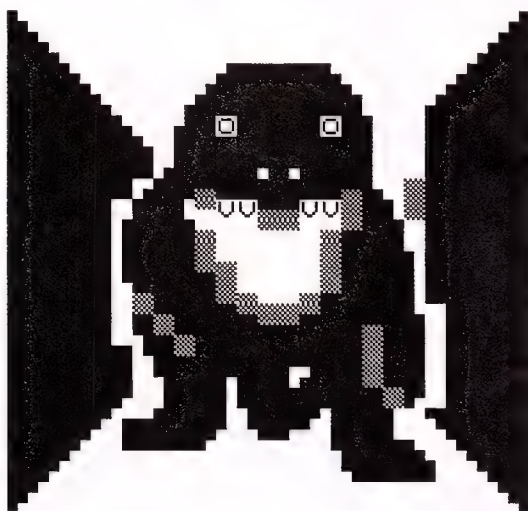
Once inside ZEsarUX, you will be greeted with a help screen, press Enter to dismiss it. ZEsarUX will probably run a ZX Spectrum by default, but you can easily switch to a ZX80 or ZX81.

If the main menu hasn't already been brought up, press F5. From the main menu, choose Machine > Sinclair Research, then pick either the ZX80 or ZX81.

The emulator will now reset into an empty BASIC prompt. Don't panic, you won't have to learn any commands. Just open the main menu again and choose Smart Load. From here, open your cassette files and it should open automatically. If your files are still zipped, ZEsarUX will simply treat the ZIP file as a folder, and you can open cassette images from within ZIP files.

If your program isn't doing anything (you may see a "0/0" message) press R, which will enter the RUN command, and press Enter. This should get you out of most jams, though it's also worth remembering the Continue button, which is mapped to the C key.

In a weird case of early British terminology, Enter will generally be referred to as "Newline". As for controls, many games will work with your PC's cursor keys – a luxury of modern emulation – but Sinclairs usually have their cursor keys mapped along keys 5 to 8: 5 = Left, 6 = Down, 7 = Up, 8 = Right. ■



SCORE
5

3D Monster Maze (1981) for the ZX81 was hailed as a technical triumph, being one of the first games with a 3D first-person perspective available for home systems.



AFTER YEARS OF STRUGGLING AGAINST DDOS ATTACKS, *TITANFALL* IS BEING REMOVED FROM SALE

Will be removed from subscription services early next year.

After years of struggling to combat hacks and DDoS attacks that at times have rendered *Titanfall* unplayable, Respawn Entertainment is throwing in the towel. The studio said in a message posted to Twitter that it is halting sales of the game and will remove it from subscription services on March 1, 2022.

The decision to end *Titanfall* sales follows a back-and-forth battle with hackers going back to 2019, resulting in a "mostly negative" user review rating for the game on Steam. There were flashes of hope earlier this year – Respawn told players that "help is coming" in April – but by mid-May the situation was as bad as ever, and in mid-July Respawn community coordinator Jason Garza acknowledged that the demands of *Apex Legends* meant that only "one or two people" were still working on *Titanfall* support.

VALVE ISN'T MAKING ANY STEAM DECK-EXCLUSIVE GAMES

Whatever game Valve releases next, you'll still be able to play it on your PC.

In a new FAQ aimed at game developers interested in the Steam Deck, Valve reiterated one of its main talking points since first revealing the Steam Deck in July: It's a PC. And because it's a PC, Valve isn't planning to develop any games that will only be playable on the Steam Deck, and it doesn't expect other developers to do so, either.

"That doesn't make much sense to us," the FAQ says about Steam Deck exclusives. "It's a PC and it should just play games like a PC."

Elsewhere the FAQ clarifies what developers and players will be able to do with the hardware. Valve didn't design the Steam Deck to play VR games, but "Technically it's possible. We've seen people jury rig it," the FAQ says.



Dark Souls named 'Ultimate Game of All Time'

Director Hidetaka Miyazaki said he was "deeply moved" by the honour.

The PC was declared the Ultimate Hardware of All Time at the 2021 Golden Joystick Awards, an obvious and completely correct acknowledgement that PCs both predate and outpace any game console you care to name. As Gabe Newell put it in his award acceptance speech, "Gamers and developers have benefited enormously from the relentless innovation in PC gaming hardware."

But if PC is the ultimate gaming hardware, then what, you might reasonably ask, is the ultimate game? That, according to the Golden Joysticks, is FromSoftware's 2011 ARPG *Dark Souls*, which beat out other contenders in the fan-voted category including *Doom*, *Half-Life 2*, *Minecraft*, *Halo: Combat Evolved*, *Grand Theft Auto 5*, *Portal*, and *Space Invaders*.

"Thank you very much for receiving such a wonderful award," *Dark Souls* director Hidetaka Miyazaki said in a statement reported by Yahoo Japan (via Google Translate). "It's still unbelievable that the user chose from the nominated works, but I feel it's a great honour."

Miyazaki also paid tribute to his colleagues at FromSoftware, saying that newcomers to the studio when it began working on *Dark Souls* are now "the core of the latest effort, *Elden Ring*."

"I was deeply moved by the award," he said. "We will continue to make interesting and valuable games. I hope you look forward to it. Thank you!"

It's interesting to recall, in light of this award, that the original release of *Dark Souls* on PC, the *Prepare to Die* edition, was really quite a mess. FromSoftware described it ahead of launch as "strictly a port from the console version," with no optimisations for PC, and they weren't kidding: Among other issues, it was locked to 720p/30fps at launch, which even in 2013 was definitely not cool. Modding hero Peter "Durante" Thoman quickly released a patch that did away with those graphical limitations, but it still suffered from wonky sound and brutally bad mouse-and-keyboard controls. It wasn't until the 2018 release of *Dark Souls Remastered* that we got an out-of-the-box experience that didn't look like it was deliberately calculated to make us all buy PS3s.

Hopefully the rollout of FromSoftware's latest soulslike will be a lot smoother: *Elden Ring* is currently set to arrive sometime in February 2022.



HORIZON FORBIDDEN WEST DEVELOPER EXPLAINS HOW IMPROVED NPCs BRING ALOY'S WORLD TO LIFE

Guerrilla has thought of every little detail.

"We're thrilled to announce that *God of War* (2018) will be coming to PC on January 14, 2022!" Sony Santa Monica Studio senior community manager Grace Orlady wrote on the PlayStation Blog. "All of us at Santa Monica Studio have been humbled by the immense amount of support and passions fans of the *God of War* series have shown in the latest chapter of Kratos' story since its release. As of August 2021, 19.5MM copies for *God of War* on PlayStation 4 have been sold through and we can't wait to share that experience with a whole new group of players on PC."

Make no mistake, this is a very big deal. Sony has previously expressed interest in bringing more of its first-party games to PC, and has recently committed to some big ones including big names like *Horizon Zero Dawn* and *Uncharted 4*. But *God of War* is not just another PlayStation game – it's a capital-P "Prestige" title that's won numerous acclaim and awards for both its axe-swinging action and its effective portrayal of fatherhood and family.

HITMAN 3 IS GETTING NEW MAPS, NEW MODES, AND NEW STORYLINES THROUGH 2022

The game's second year features "a few surprises" that fans have been asking for "for a very, very long time".

In a new trailer, developer IO Interactive outlined *Hitman 3*'s second year. Starting in January with VR support on PC (on top of the currently-available PlayStation VR) and an elusive target 'arcade' which will put a spin on the limited-time marks, there'll also be ray-tracing on PC coming in "early 2022."

On top of that, CEO Hakan Abrak said that "new maps, new storylines, new modes, new ways of playing" would all be coming in 2022, as well as "a few surprises that our community has been asking for, for a very, very long time."

There's no word on what shape those surprises might take, but hopefully we'll begin to see them around the time of the secretive spring update mentioned on the developer's website. It's also no surprise that development would be continuing on the game, as the studio announced that the 'World of Assassination' trilogy that kicked off with the *Hitman* reboot in 2016 had reached 50 million players, with *Hitman 3* topping the list as the most successful *Hitman* game ever.



NEW LEAK SUGGESTS RESIDENT EVIL 4 VR WILL GET FREE MERCENARIES DLC NEXT YEAR

It looks like fan-favourite Mercenaries mode is coming to *Resident Evil 4 VR*. Though not formally confirmed by Capcom – in fact, there's been no formal mention of Mercenaries at all at this point – Biohazard Cast (thanks, UploadVR) spotted a teaser advertising that the new mode is coming to the Oculus Quest 2 exclusive VR port next year.

MASS EFFECT LEGENDARY EDITION MIGHT BE COMING TO XBOX GAME PASS

Though not officially confirmed by either Xbox or EA – which means we can only report this with the usual bucketload of cynical salt for now – a Polish site, XGP, reckons it spotted that the remastered trilogy briefly had a Game Pass badge on its Microsoft store listing in late November. ■



\$99.95 | PC | ageofempires.com

Age of Empires IV

The unique civilisations are the stars, showing that less is more.

With *Age of Empires II* still held up as a paragon of strategy games, you can see why new series developer Relic has decided to model *Age of Empires IV* on the second entry. The latest iteration strips away the complexities of *AoE III*, while adding welcome touches of its own. Chief among these are asymmetrical factions, which will elicit screams of bloody imbalance but count as the game's greatest success.

On the other hand, reverence to the past can be restricting, and I can't help but feel that *Age of Empires IV* could have been something more. Instead, there's a staid utilitarianism throughout much of *Age of Empires IV* – everything in it works much as it ever did, but without the flair that could have made it a grand celebration of that timeless *AoE* formula.

The campaigns follow the Normans, Mongols, Rus, and English across three distinct eras each. The campaign throws up plenty of great set-pieces; there's the Battle of Xiangyang to establish Kublai Khan as Emperor of China, Dmitry Donskoy's power-shifting defeat of the Mongols at Kulikovo, and over in the west the Battle of Bremlé to

establish England as a regional power. These missions aren't easy either – on standard difficulty I found I had to quickly wrap my fingers around the new keyboard shortcuts to keep up.

The Mongols are the biggest wildcard, capable of packing entire towns up into carts and relocating to anywhere on the map. For a simpler player like me, the Delhi Sultanate, with its war elephants and research system based around scholars, was a hoot, while the Rus accrue gold through hunting cabins and bounties.

Sieges feel much better thanks to the ability of infantry units to create battering rams and siege towers. It does wonders for the pacing that you no longer have to guide your siege equipment across an entire map. Positioning soldiers on walls defensively, on the other hand, offers increased sightlines, and I shamelessly exploited this against the AI by building stone walls right up in their business, picking off key economic buildings with wall-mounted archers.

Finally, the ability to quickly rotate and position unit groups on an axis is great for battle micromanagement, letting you



Top: Piling in on the French city of Bayeux as Henry I in the Norman campaign.

Above: A Holy Roman battalion made up of Men-at-Arms and Landsknecht made quick work of the Chinese.

set up defensive positions or proper army formations more elegantly than before. These aren't huge changes, but they all help the combat feel that bit cleaner.

In a series where a single game can take years, even decades, to evolve into its final form, the only thing really standing in the way of *Age of Empires IV*'s growth is the ongoing success of its predecessors. It offers enough new ideas amidst the sturdy old foundations to rank among them, though it's not yet ready to rule.

A worthy new entry in the series that's equal parts progressive and dated. It could've been far better if it was bolder.

Robert Zak

★★★★★



apc

EDITOR'S CHOICE

\$89.95 | PC, XBOX/S, XB1 | xbox.com

Forza Horizon 5

More of the same, and that's OK.

Forza Horizon 5 doesn't need to do what other racing games would do. It just needs to be a *Forza Horizon* game. It's a series with no serious rival, and as such it feels unchallenged. It's not being forced to reinvent the wheel, and so it's content to just hone and refine – to be the best *Forza Horizon* it can be.

If you have played any previous *Forza Horizon* games you already know what this means. A map filled with more icons than a Ubisoft open world, each denoting a race event, a PR stunt, a rumour about some vintage car, or a series of challenges organised into a handful of stories. As you win races and complete events, you're bombarded with rewards. You earn accolades – mini achievements that act as *Forza Horizon 5*'s career progression system – some of which reward new cars and new phrases to spam in chat. You earn wheelspins that can drop cars, cash and clothes. The rewards come so thick and fast, that collecting new cars is more about broadening your options than straight progression.

The major new feature of *Forza Horizon 5* is, simply, its setting. Mexico is more varied and vibrant than *Forza Horizon 4*'s UK – with rainforests, towns, deserts, and many, many cacti to bash into. The weather is more interesting too.

This is *Forza Horizon*'s whole deal, though, and while I might roll my eyes at the dialogue, I can't pretend I don't get swept up in the atmosphere. Inevitably as I play, I have a big, dumb grin on my face. It's just that kind of game. Similarly, I can't really criticise it for not innovating the series – making big, sweeping changes for the sake of it feeling more different. It's easy to forget given how effortless everything feels, but the sheer detail of its environments and the level of craft evident in each of its over 500 cars is astounding.

The series gets a new, lush setting, but otherwise is content to simply fine-tune an already winning formula.

Phil Savage

★★★★★

Top: Live out your fantasy of crashing some of the world's most expensive cars.

Above left: *Forza Horizon 5* has no chill.

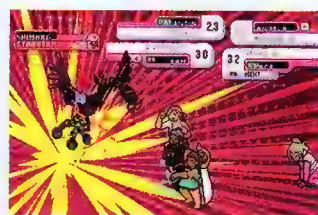
Above: Street races are dangerous. Everyone here should go to jail.

Driving down a big volcano is as much fun as it looks.



apc

HIGHLY RECOMMENDED



Free | PC, Mac | bit.ly/CarLoser

GET IN THE CAR, LOSER!

Fate can do one.

This is literally a road trip, where you hop from gas station to gas station on a straight stretch of road, while beating up demons.

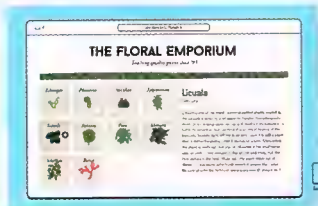
The title is taken from the opening scene, where shy protagonist Sam is picked up by a friend and her boyfriend, before being dragged into an adventure to save the world. You see, Grace has stolen the Sword of Fate, and plans to use it to destroy the evil Machine God, whose followers are a bunch of creeps. Hot on your heels are agents of the Divine Order. If it sounds like a clichéd JRPG story, rest assured that it's full of funny, rude, and quotable dialogue, and much more focused on its likeable characters than the overarching plot.

Combat is energetic and innovative, supported by sumptuous pixel art and a banger of a battle theme. However, with little downtime in the game – there are no dungeons to explore, or towns to poke around in – it can feel like a relentless deluge of banter and battles.

Inventive, stylish and actually crackling with energy, *Get in the Car, Loser!* is an order you should follow.

Tom Sykes

★★★★★



Free | Browser
crystalclod.itch.io

THE FLORIST

**Definitely not
murdering
houseplants.**

The Florist is a game about being in a trendy apartment: a haven of tranquillity in a busy city. There's no TV to distract you, although you can play classical music, and bury your nose in a selection of stories from long-dead authors. If you want, you can try to keep your grandma's houseplants alive.

To that end, she sends you a parcel containing fertiliser and a jug. Each plant has different needs. Luckily, you can open the laptop to view a handy guide. As the days turn to weeks, your gran will post ever more fragile plants for you to look after. You'll also get letters, and occasionally books, in the morning mail.

It's a game that would play best in quick daily bursts, which is why it's disappointing that *The Florist* doesn't include any way to save your game. But if you can play it all at once, or leave it running while you do other stuff, it's pretty satisfying trying to keep the things alive.

A game as simple and relaxing as watching the plants grow.

Tom Sykes

★★★★☆



apc
HIGHLY
RECOMMENDED

\$29.49 | PC, PS4, XB1, Switch | circuit-superstars.com

Circuit Superstars

Bad news, sim racing fans.

Top: Listen, third out of four is actually very respectable.
Above: The more you drive, the more customisation options unlock.
Above right: I... may have missed my pit box just by a hair.

This gem is a mix of arcade and sim racing that feels enriched, not compromised, by both. This may look like an unassuming title, and certainly it launched to little fanfare, but it deserves the attention of any motorhead. If you're a veteran of many a cross-legged *Micro Machines* campaign from the 16-bit days or, to be honest, if you've simply glanced at the screenshots, you've got a handle on how it feels to drive. What isn't evident until your first race is the sheer amount of subtlety baked into those adorable little vehicles. Going fast here is about picking out and committing to perfect racing lines, keeping all inputs smooth, and holding onto momentum.

It is, I'm really surprised to discover, my favourite racing game for years. Tracks rubber up as the laps go by, revealing thick, tar-like stripes of freshly laid tyre where extra grip and lap time can be found. Conversely, in events with tyre deg enabled, you'll lose pace alarmingly quickly unless you focus your driving style on modulated throttling and minimal steering under throttle or braking.

Another part of your brain is still keeping an eye on fuel. In a

game that looks like this, remember.

Developer Original Fire finds a style of track design that works really well with both its camera perspective and vehicle physics, and in its 12 circuits – with 18 total layout variations – lies a long-term challenge. Mastering the lines well enough to perform respectably online, and fine-tuning that muscle memory in search of time trial leaderboard perfection.

It's a pretty light online proposition. It's a shame that even with an online lobby feature that lets you buddy up as a party of four, you still have to race in public lobbies with up to eight strangers, and can't create your own event types from scratch.

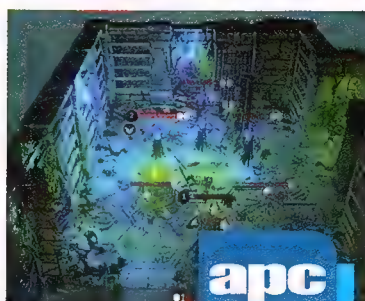
Somehow, using some cute little cars, a camera perspective from the arcades of yesteryear, and surprising sim touches, it makes all-out racing sims feel a bit like doing a yearly tax return by comparison.

Please make more games, Original Fire.

Show the rest of the genre how sim meets arcade is done.

Phil Iwanik

★★★★☆



\$49.95 | PC | asmodee-digital.com/en/gloomhaven

Gloomhaven

Brilliantly translates the beloved board game to your PC screen.

Dungeon-crawling, campaign-adventuring *Gloomhaven* is surely the most widely-praised hobby board game of the past decade. The digital edition replicates the sprawling *Gloomhaven* campaign in its entirety, adds an entirely new second mode of play called Guildmaster, and networks them both with online multiplayer: an adaptation of the tabletop experience that leaves nothing behind. Nonetheless, occasional poor performance, the lack of key features like undo, and a healthy sprinkling of bugs hold *Gloomhaven* back.

Gloomhaven is at its heart a dungeon crawler, where framing stories read by a narrator sit alongside missions that take adventurers through a series of rooms and monsters to accomplish fairly simple objectives. Everything in between quests is a choose-your-own-adventure, where decisions are made and give static bonuses or penalties to either the campaign as a whole or the next adventure. Both modes can be played by yourself controlling one to four adventurers, or with up to three others controlling one each.

Dungeons are card-driven

tactical battles, some of the best you can find, that use a flexible system where you choose two cards each turn, then execute the action from the top of one card and the bottom of the other. Monsters play out simply, no complex AI here, but each round is planned in advance: you don't know what the monsters are going to do until you've locked in your options. Each card also has a numerical value, its initiative, which is when you act in the round.

These fairly simple rules make fights into a slew of tough tactical choices and tight time limits in any given fight. Missions are hard, and even the base easy difficulty can and will beat tactics veterans into a pulp. A single misplayed turn can set you on the path to doom in some scenarios, as a tight timeline combines with a limited number of cards to burn before you're out of the fight entirely. It's some of the best tactical play in gaming, and some of the most delightfully difficult choices you'll ever make in a dungeon crawler.

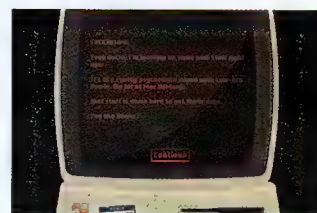
One of the best dungeon crawlers ever made is now on your PC and is brilliant, especially if you don't own a big table.

Jon Bolding

★★★★☆

Above left: It's a faithful adaptation, but with some clever additions and changes.

Above: Every battle is its own tactical puzzle to figure out.



Free | Browser

tim-sheinman.itch.io

ECHO BEACH

Imagine a future without music.

Echo Beach is set in a future where music is banned, and where rogue musicians are hunted down by undercover agents. You play as one of these agents, and your job is to infiltrate an online community, reading messages and listening to music for clues to their identities. Every time you work out a name, you feed the information back to your superiors, who will arrest the musician and give you new targets, the following day.

There are few other games where you feel as much like a detective, poring over messages and replaying songs for clever lyrical and sound-based clues. I just wish I'd been able to solve them. Perhaps I'm tone-deaf, and unable to keep time, but I hit a brick wall when asked to locate a drum tempo, and chords, by listening to the playlist. I think that's 67 BPM, but the game doesn't seem to agree. These are not solutions you can brute-force, and that's to *Echo Beach's* credit, but it did feel like I'd been kicked out of the party halfway through.

A novel and compelling detective game with a twist.

Tom Sykes

★★★★☆



Don't do drugs, kids - or else.

GAME CHANGER

Sin

Phil Iwaniuk remembers the last shooter of the pre-Half-Life world.

RELEASE 1998 DEVELOPER Ritual Entertainment PUBLISHER Activision LINK bit.ly/3krVRVs

On November 19, 1998, Sierra released *Half-Life*. In the time it took to install 300MB of exquisitely poised shooter off its CD-ROM, everything from the genre prior became part of a bygone era. And perhaps the unluckiest of the lot was Ritual's *SiN*, which released just ten days before it.

Here was a game that, like *Half-Life*, wanted to bring a bit more storytelling back to the genre after a long period of dominance from dialogue-averse id Software and similarly laconic newcomers Epic Games. It had a spectacularly named hero in John Blade, and in its antagonist Elexis Sinclair a typically salacious depiction of a woman – though to give Ritual some credit, both black player-characters and female CEOs were wildly progressive ideas for the era. It had voice actors. It was set in a recognisable near-future. There wasn't an inverted cross,

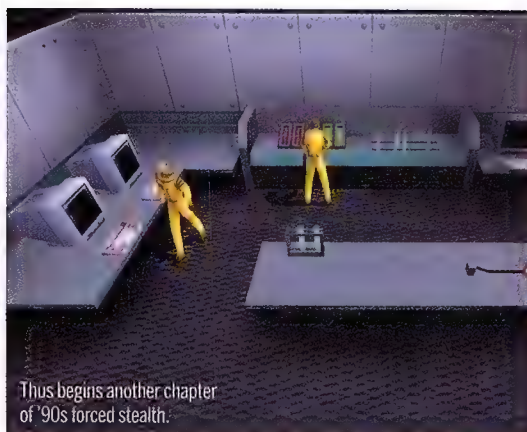
alien landscape, or power-up in sight. If John Romero wasn't already turning in the grave he was slowly digging for himself at Ion Storm, the posters on *SiN*'s walls hilariously stating 'Lex to make Romero her bitch' on them would have sealed it.

Though it was destined to be forgotten in Gordon Freeman's wake, the story goes like this: billionaire biotech company owner and apparent PVC fetishist Elexis Sinclair is making dangerous drugs that mutate humans into giant veiny hitboxes down in the Sintek labs. Freeport City PD's finest and most implausibly musclebound colonel John R Blade gets wind of the scheme when his Hardcorps team is called into a bank robbery led by a mob boss who abruptly erupts into something beastly and inhuman mid-chase. Blade, with hacker sidekick JC in his earpiece and splicing into various mainframes

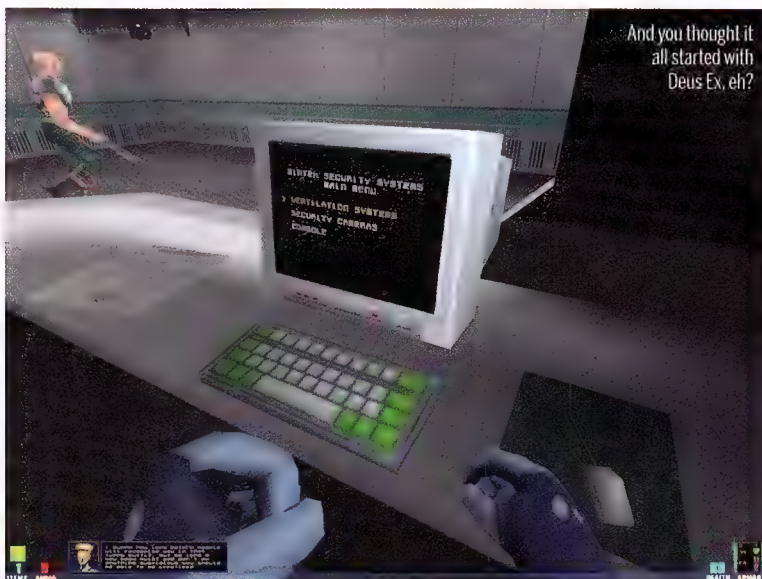
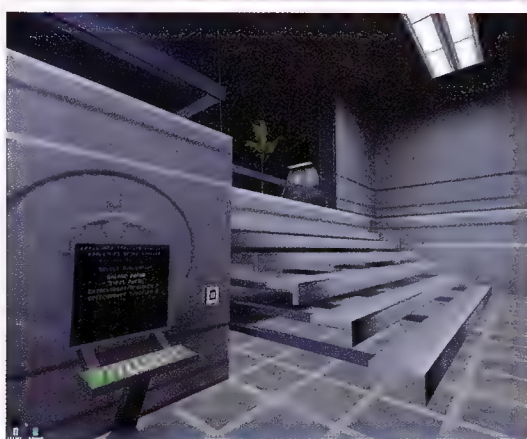
from back at headquarters, must track down the supply of the street drug U-4 causing the mutations and take down Sintek.

Not one for the Booker shortlist, but *SiN*'s great appeal was, and remains, the sheer exuberance with which it goes about telling that tale. It's a game full of moments that clearly, transparently began with someone at Ritual saying, "It'd be cool if..." Design document be damned. Market research can do one. What can this new toy of 3D interactive space do?

It can drop you from a helicopter into a bank heist in progress. It can turn a construction site shootout into a platforming puzzle, and then throw a driveable digger in there purely to allow the player to bash a hole in the wall in real-time, then get out, and never operate another vehicle again. What was a bombastic corridor shooter in a subway station five minutes ago



Thus begins another chapter of '90s forced stealth.



And you thought it all started with Deus Ex, eh?

becomes a stealth game that asks you to sneak around the Sintek labs with nothing but judicious use of the crouch button to mask your presence.

Creeping death

That stealth section, just five missions into the story, proved an impasse for me at the time of *SiN*'s

release. It's tricky to shuffle around the many high-identical rooms of the laboratory and tick off the mission objectives without a single NPC, guard or camera spotting me now. To 13-year-old hands in '98, it was unassailable. It would be months before I'd get to see its later levels. Months spent in the uncaring vision cones of Sintech's

spider robots and wall-mounted miniguns. The indignity of Mr Blade himself sliced and diced by high-calibre rounds. Modern sentiment towards such a hurdle at the hands of clumsy stealth mechanics would be damning, but you didn't simply excommunicate a game for trying something in the beige age.

Besides, I'd previously spent several days stuck on a construction site puzzle that required you to look up and shoot a girder out of the sky in order to rupture a water pipe at your feet, allowing Blade to swim out of the hole he was in. And another few days figuring out a platforming run behind some loose bricks and ascending the floors of a derelict building in the precious few seconds before a bomb went off. What was another few weeks reloading the same quicksave?

Sinclair spectrum

After clearing the stealth mission though, *SiN*'s digressions from the corridor shooting vogue of the time are fewer. Levels within Sinclair's wicked facility can come and go with little imprint on the memory. There's a sense that after

YEAR OF THE GUN *A timeline of shooters from 1998*



UNREAL
MAY 22

Wake up on a wrecked prison space ship, meet Skarj, shoot Skarj, look incredibly at nice water. Pretty shallow, but *Unreal* made a leap forwards visually from incumbent FPS king *Quake II*.



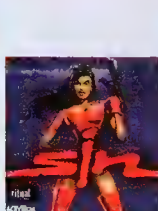
TOM CLANCY'S RAINBOW SIX
AUGUST 21

Guns, yes, but also: tactics. A revolutionary idea only diminished by the clumsy planning stage which worked a bit like giving RTS-style orders then executing them.



SHOGUN
M.A.D.
SEPTEMBER 30

Mechs, yes, but also: guns. Will the revolutionary shooter ideas never cease this year? Monolith's take on the FPS stood apart from the *Quake* clones. Also about 20 feet taller.



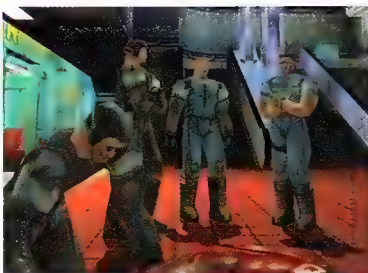
SIN
NOVEMBER 9

As *Quake* and *Unreal* dialled back exposition and dialogue, *SiN* wanted to take FPS gaming in a more cinematic direction. Characters, plot, set-pieces... it was a grand plan.



HALF-LIFE
NOVEMBER 19

It upstaged *SiN*. It made *Unreal* feel like a tech demo. *Tom Clancy's* waypoints and *Shogun's* mechs were laid to waste. So were the next 300 shooters. Gordon changed it all, forever.



the freewheeling nature of its opening levels, any further conversations that began, “It’d be cool if...” ended with, “Yeah, but we ship in two months.” Laboratories give way to warehouses and sewage works that might be visiting from any number of other shooters from that period, before *SiN* seems to remember itself again and start flinging absurdly and hilariously disparate locations at you. Oil rigs. Jungle. The ocean floor. All perfectly reasonable places for a policeman to visit in pursuit of an evil biotech boss.

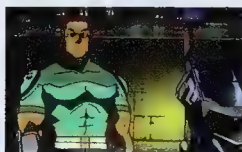
years later it's still unclear what the advantage is of doing this, or why Ritual saw fit to include it in the game. Like so many of *SiN*'s extraneous touches, I'm very glad they did.

Most lavish of all is the training facility, a lovingly constructed tutorial area that many players

What Ms Sinclair did next



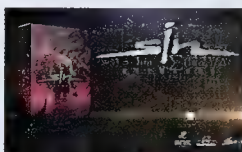
An expansion pack that pits John Blade against a crime boss who wants to take over Freeport.



Despite carrying the name, the animated movie adaptation plays pretty fast and loose with canon.



An episodic sequel with only one episode, titled 'Emergence'. Poor sales did for the rest.



ON RECORDED 2022!
A Night Dive remake running on the studio's Kex Engine, coming out soon.

would wilfully breeze past on the way to a new game, or fail to spot on the main menu screen. Anyone who does would miss out on the skeet shooting and sniping ranges, the shooting galleries where cardboard terrorists and civilians pop up, and the inconspicuous buttons on the wall that deploy bleachers from the wall, as if all of John's buddies are about to down tools and watch his mastery. Before you even get on the helicopter to that bank, you're sold on the future-cop fantasy.

Blade runner

Before you install the game, the fun starts. *SiN*'s manual sets the scene before disc ever meets disc tray, detailing Blade's troubled dreams and disturbed visions in diary form. A life on the beat, it appears, has taken its toll on the man's psyche, and the appearance of a new street drug that makes monsters of people has done nothing to take the load off.

He's quite a talented sketch artist too, is John. The nightmare visions he puts into form, all bulging eyes and blood vessels, are expertly drawn, if partially obscured by the manual's faux coffee rings.



Just another day for this
guy down the mutant
warehouse.

Most lavish of all is the training facility, a lovingly constructed tutorial area that many players would wilfully breeze past on the way to a new game, or fail to spot on the main menu screen.

Quite why Elexis Sinclair wants to make monsters of people, all bulging eyes and blood vessels, is a question *SiN* barely scratches. She's evil. She's super-rich. Her eyebrows arch at an especially cruel angle. That's all the insight as we get into the chief antagonist, which is as much of a shame as the asphyxiating latex she's almost always wearing. As if a buttoned up blouse and pantsuit would have been the difference between playing it and leaving it on the shelf.

Blade and JC fare much better under deeper character scrutiny. In keeping the cocksure young hacker away from the action and thus safe to chip in frequent jibes at his enormous boss, *SiN* finds a way to bring in some buddy cop comedy and make it the game's own.

Having JC there to observe the extraordinary events you're shooting through and then banter with you elevates the story beyond its prosaic plotting. Without a spiky haired white hat watching,

Blade would get away with donning a lab tech's yellow overalls to disguise himself without ridicule. And that would be infinitely duller. As a helpful objective reminder and mechanic explainer, he's there to address the player as much as the protagonist, but in the end it's JC's warm and insouciant bro-ing out with Blade that stands as one of the game's more enduring components.

Age of innocence

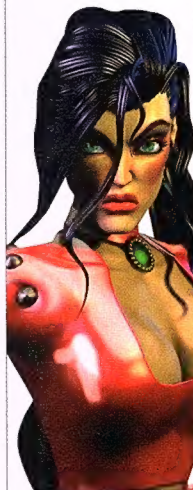
It's natural to feel nostalgic for this halcyon period of PC gaming, particularly since it's been so adept at archiving and updating itself over the years – *Night Dive* just released a Gold version to Steam featuring the *Wages of SiN* expansion, and plans a full remaster soon. But the exact nature of what was so good about those days anyway can be hard to pinpoint.

Enter a wobbly *Quake II* engine shooter, all ideas and precious little polish, that serves a handy

reminder that a crucial player in the PC gaming golden age was naivety. Ideas, set-pieces, and mechanics thrown in with reckless vigour and scant regard for timelines. Modern game dev is smart and efficient. *SiN* had fully animated bleachers in the skeet shooting range of its optional police training level.

Not that we lavished praise on this game and its ilk for their generosity at the time, you understand. This extravagance is something you can only get a sense of by playing a game now. No, at the time everybody was much too annoyed by the absurdly long load times – and subsequently bewitched by *Half-Life* – to appreciate *SiN* for what it was. The last luddite shooter before the industrial age, happy just to give you a handgun bigger than your entire forearm, a screen full of identical goons, and a driveable JCB you operate for five seconds then park up forever.

Night Dive's typically sterling work means it's perfectly preserved for modern systems and, finally, easy to run on widescreen monitors. But Ritual's plaudits are long overdue for crafting a shooter whose charms and replayability far exceed our estimations in 1998. ■



CHIP CHAT

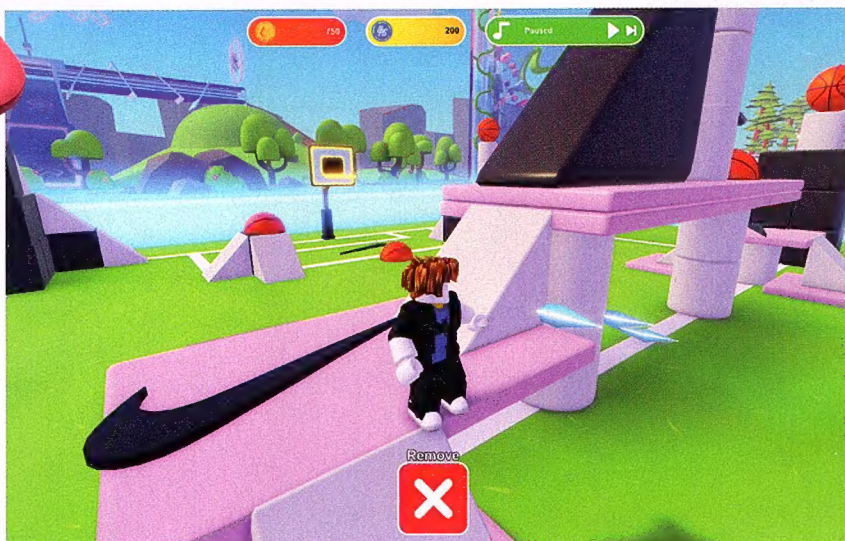
JOEL BURGESS REPORTS ON THE UNUSUAL SIDE OF TECH NEWS



LOGITECH POP KEYS AND MOUSE

All the feels at your fingertips.

If you were sad about Apple's decision to ditch the Touch Bar on the new line of MacBook Pros, then now is the perfect time for some retail therapy from your favourite peripheral maker: Logitech. The Logitech Pop mouse and keyboard range feature mappable keys so you can add all your essential emoji responses directly to your interface options. The devices come in three lit colour schemes: love-heart eyes, fire and heavy tears, which Logitech incorrectly dubbed Daydream, Blast and Heartbreaker, respectively. The Pop Keys also offer mechanical switches, even though they're pitching to a generation that hasn't been around long enough to have ever used non-digital mechanics, let alone develop nostalgia for them.



Nikeland

Nike and Roblox team up to build the future.

Meta seems to think that it's got a shoe in for the best metaverse of tomorrow, but as Rickey Bobby says "if you ain't first, you're last" and Nike is pushing hard to ensure they've got one of the first metaverses around. Nikeland, the inevitable title of the first Nike-backed metaverse, is built on the premise that you'll be keen to play other people's poorly designed sports games and walk around Nike's digital showroom in exchange for a pair of digital sneakers to put on your Avatar. It sounds too good to be true right?



DECENTRALAND SELLS US\$2.4M PLOT OF VIRTUAL LAND

The blockchain based metaverse has a hot property market too.

It might seem like buying a multi story shopping centre on 6,090 square feet of one of the hottest plazas in 'Shopping Street' for just US\$2.4 million is a bit of a bargain, but that's until you realise that this is a piece of digital real estate. The items in Decentraland's metaverse have been forged using Ethereum contracts that allow them to be securely traded and exchanged on the blockchain. They're basically NFT's that you can build on and avatars you can interact with. US\$2.4m is undoubtedly an eye watering amount to pay for this emerging technology, but if Decentraland is destined to become the New York city of the metaverse then it's possible that it really is a bargain.



DOOM RATS LEARN TO PLAY IN VR

Rodents trained to play Doom II.

Neural engineer Viktor Tóth created a contraption that trains rats to play *Doom* on a giant screen. The rats use a large ball treadmill placed in front of a screen to move the character around the *Doom II* map and are rewarded with water and food via a tube for shooting monsters. Apparently rats are colour blind so the simple *Doom II* graphics are well suited to being perceivable by them and the rats can be taught to traverse complex terrain maps using the device. Tóth's VR interface can be constructed for under \$2,000, making it much cheaper than other rodent training devices. ■

THE FUTURE OF MAGAZINES



➤ Subscribe at www.techmags.com.au

Free delivery across Australia | Never miss an issue | Save money

GIGABYTE™ | intel®



15"/17" AERO creator laptop
Creativity Starts Here

BE ALPHA

4K

SAMSUNG
AMOLED



VESA CERTIFIED
DisplayHDR™ 400

The all-new AERO creator laptop has a performance upgrade with the 11th Gen Intel® Core™ H-series processor. The elegant and powerful design is paired with an unparalleled 4K HDR visual experience, bringing users a faster, smoother, and more immersive creative journey.

